JANUARY 1957

Journal

VOL. 49 • NO. 1

AMERICAN WATER WORKS ASSOCIATION

In this issue:

Hydraulics electrified: Network analyzer installed at Philadelphia

Journal

AMERICAN WATER WORKS ASSOCIATION

2 PARK AVE., NEW YORK 16, N.Y. • Phone: MUrray Hill 4-6686

January 1957

Vol. 49 • No. 1

Contents

Departments

HARRY E. JORDAN, *Secretary*

ERIC F. JOHNSON, *Asst. Secy.—Publications*
LAWRENCE FARBER, *Managing Editor*
COLLIN GONZE, *Assistant Editor*
PHILIP RESSNER, *Assistant Editor*

Journal AWWA is published monthly at Prince & Lemon Sts., Lancaster, Pa., by the Am. Water Works Assn., Inc., 2 Park Ave., New York 16, N.Y., and entered as second class matter Jan. 23, 1943, at the Post Office at Lancaster, Pa., under the act of Aug. 24, 1912. Accepted for mailing at a special rate of postage provided for in paragraph (d-2), Section 34.40, P. L. & R. of 1948. Authorized Aug. 6, 1918. $7.00 of members' dues are applied as a subscription to the JOURNAL; additional single copies to members—60 cents; single copies to non-members—85 cents. Indexed annually in December; and regularly by *Industrial Arts Index* and *Engineering Index*. Microfilm edition (for JOURNAL subscribers only) by University Microfilms, Ann Arbor, Mich.

AWWA Officers and Directors

President	Paul Weir	*Past-President*	F. C. Amsbary Jr.
Vice-President	Fred Merryfield	*Treasurer*	William W. Brush
Ch. W.W. Practice Com.	Louis R. Howson	*Secretary*	Harry E. Jordan
Ch. W.W. Admin. Com.	Wendell R. LaDue	*Exec. Asst. Secretary*	Raymond J. Faust
Ch. Publication Com.	E. Shaw Cole	*Asst. Secretary-Pub.*	Eric F. Johnson

Officers of the Sections

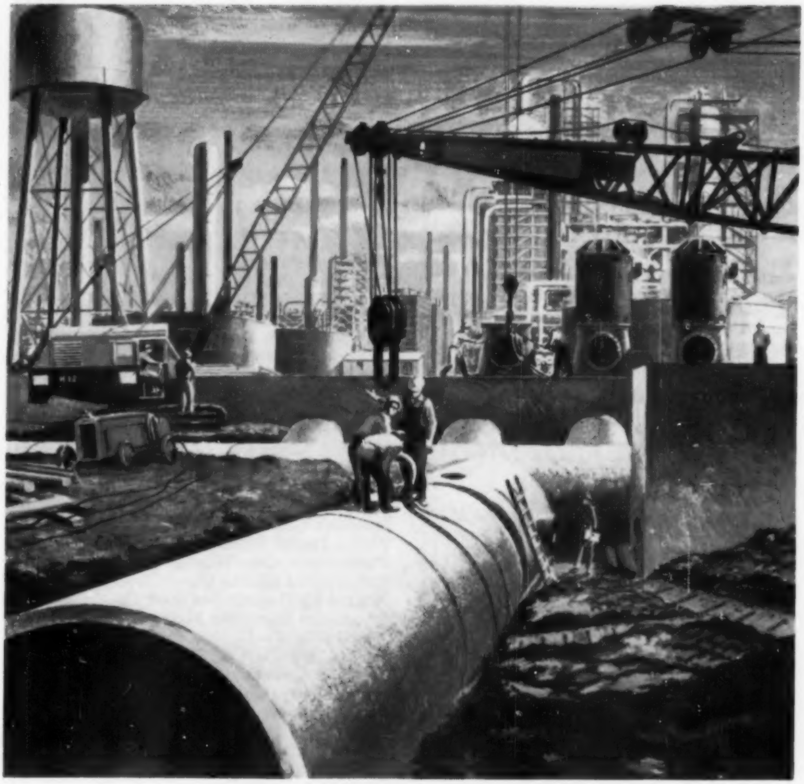
Section	*Director*	*Chairman*	*Vice-Chairman*	*Secretary-Treasurer*
Alabama-Miss.	E. M. Stickney	H. L. Burns	W. E. Hooper	C. M. Mathews
Arizona	Dario Travaini	M. V. Ellis	Q. M. Mees	H. C. Bigglestone
California	B. S. Grant	M. J. Shelton	D. A. Blackburn	H. J. Ongerth
Canadian	C. G. R. Armstrong	V. A. McKillop	H. P. Stockwell	A. E. Berry
Chesapeake	David Auld	J. C. Smith	A. B. Kaltenbach	C. J. Lauter
Cuban	G. A. Bequer H.	M. F. DeVera	Luis Radelat	C. M. Labarrere
Florida	W. W. Gillespie	Stanley Sweeney	H. D. Overhiser	J. D. Roth
Illinois	E. E. Alt	G. L. Davis	C. L. Baylor	D. W. Johnson
Indiana	C. E. Williams	C. E. Robbins	R. G. Rinehart	R. J. Becker
Iowa	C. W. Hamblin	P. F. Morgan	G. C. Ahrens	J. J. Hail
Kansas	H. W. Badley	B. H. Van Blarcum	R. F. Bluejacket	H. W. Badley
Kentucky-Tenn.	Elmer Smith	R. A. Fischer	J. W. Lovell	J. W. Finney, Jr.
Michigan	E. D. Barrett	W. E. Smith	R. E. Hansen	T. L. Vander Velde
Missouri	H. O. Hartung	F. J. McAndrew	C. R. Hayob	W. A. Kramer
Montana	C. [illegible]. Eyer	B. F. Chestnut	R. G. Cronin	A. W. Clarkson
Nebraska	Bert Gurney	C. L. Fisher	George Beard	J. E. Olsson
New England	E. S. Chase	J. H. Robinson	F. J. Thiery	J. E. Revelle
New Jersey	C. J. Alfke	H. M. Ohland	M. E. Flentje	A. F. Pleibel
New York	J. G. Copley	F. D. Behan	L. J. Griswold	Kimball Blanchard
North Carolina	W. M. Franklin	C. W. Mengel	W. F. Stokes	W. E. Long Jr.
North Central	L. N. Thompson	H. H. Behlmer	M. D. Lubratovich	L. N. Thompson
Ohio	C. E. Beatty	M. W. Tatlock	H. C. Growdon	M. E. Druley
Pacific Northwest	E. J. Allen	C. R. Harlock	H. J. Donnelly	Fred D. Jones
Pennsylvania	L. D. Matter	B. F. Johnson	G. E. Arnold	L. S. Morgan
Rocky Mountain	G. J. Turre	Harry Barnes	W. F. Turney	J. W. Davis
Southeastern	Sherman Russell	C. C. Lanford	L. E. Wallis	N. M. deJarnette
Southwest	J. R. Pierce	H. R. Street	Q. B. Graves	L. A. Jackson
Virginia	E. C. Meredith	W. W. Anders	E. C. Coalson	J. P. Kavanagh
West Virginia	W. S. Staub	C. C. Coffield	Wallace Grant	H. W. Hetzer
Wisconsin	J. C. Zufelt	J. E. Kerslake	H. E. Wirth	Harry Breimeister

Directors Representing the Water and Sewage Works Manufacturers Assn.

Carl N. Brown　　Robert F. Orth　　R. S. Rankin

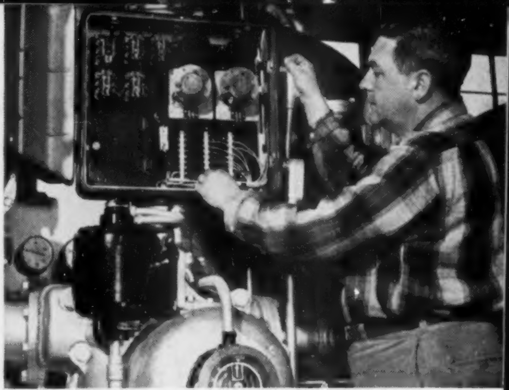
Officers of the Divisions

Division	*Chairman*	*Vice-Chairman*	*Secretary*
Water Distribution	H. W. Niemeyer	E. J. Allen	J. B. Ramsey
Water Purification	H. H. Gerstein	P. D. Haney	Sherman Russell
Water Resources	H. C. Barksdale	C. H. Bechert	J. W. Cramer
Water Works Management	L. W. Grayson	W. W. DeBerard	J. D. Kline



LIST OF ADVERTISERS

Directory of Professional Services—pp. *55–60 P&R*



HARDNESS TESTER (left) initiates regeneration by Automatic Controls (right). This new Permutit plant, with Q resin, softens 72% more water—using same manpower, less salt! E. Aurora, N. Y. Village Eng.: *E. J. Maurer.*

Why these cities chose PERMUTIT® water conditioning

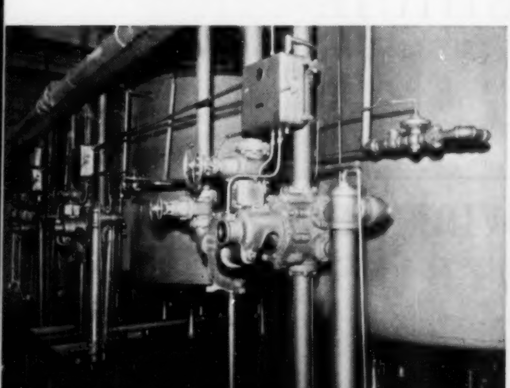
Some chose Permutit for its world-known engineering experience gained through thousands of installations covering every major development in clarification, filtration and softening equipment.

Others chose Permutit to get complete, integrated service: the water-analysis labs, engineering, equipment, controls, ion exchange resins—all from one source, under one responsibility.

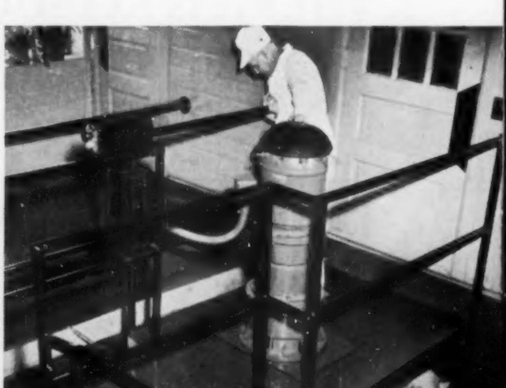
But most of the designers of these plants chose Permutit because they have personal knowledge of many installations where Permutit equipment has given long years of efficient, trouble-free performance. They know that's what pays off in the long run.

Write for Technical Bulletins. The Permutit Company, Dept. JA-1, 330 West 42nd St., New York 36, N. Y.

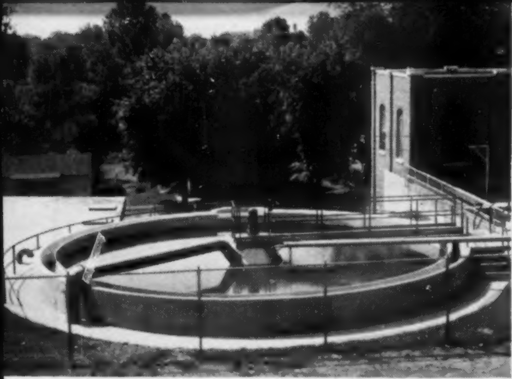
SOFTENERS • ZEOLITES and RESINS • AUTOMATIC CONTROLS • GRAVITY FILTERS • PRESSURE FILTERS
PRECIPITATORS • CHEMICAL FEEDERS • AERATORS • SWIMMING POOL SYSTEMS • IRON REMOVAL EQUIPMENT



SOFTENER CAPACITY TRIPLED and $7,000 yearly saved on salt by change from zeolite to Permutit Q. Normal, Ill. Cons. Eng.: *Farnsworth & Conley.*

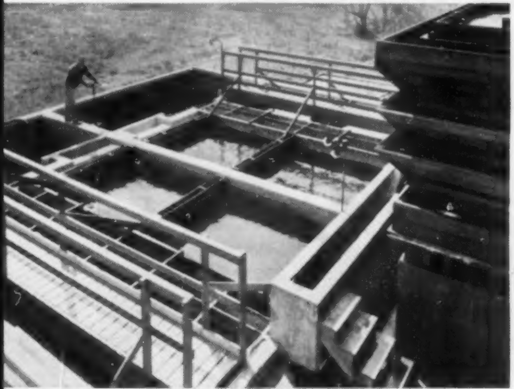


TRIPLE TROUBLE! 275 ppm hardness, 200 ppm alkalinity, 3 ppm iron are reduced by this Precipitator. Staples, Minnesota. Supt.: *E. H. Klang.*

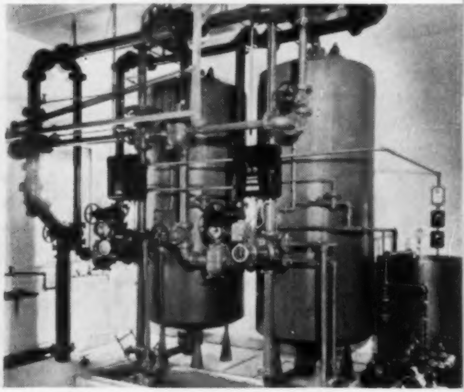


TURBIDITY gets cut from 1500 to less than 5 ppm in this Precipitator. Mt. Carmel, Ill. Cons. Eng.: *Warren & Van Praag, Inc.*

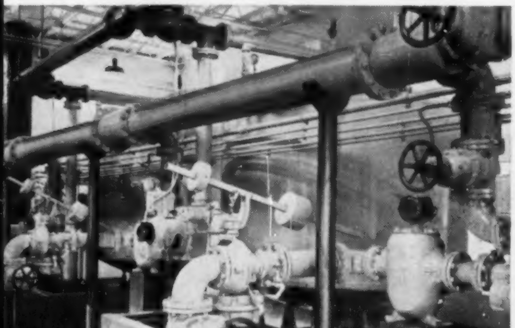
SEA WATER saves $32,980 per year over salt for regenerating Softeners. Hollywood, Fla. Cons. Eng.: *Reynolds, Smith & Hills.*



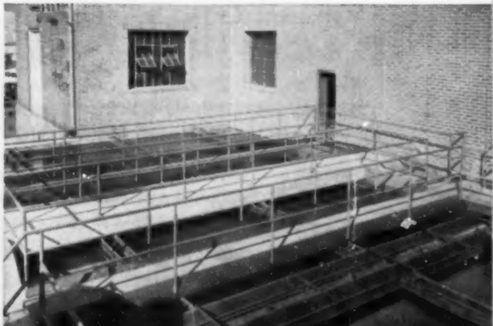
30 PPM IRON gets cut to 0.14 ppm in Aerator and Precipitator . . . even before filtration! Fairless Hills, Pa. Cons. Eng.: *H. H. Le Van, Jr.*



269 PPM HARDNESS is removed by these automatic Softeners. Aerator and Filters cut iron. Martinsville, Ill. Supt.: *O. Wiser.*



AUTOMATIC CONTROLS backwash, regenerate, rinse and return Softeners to service. New Smyrna Beach, Fla. Cons. Eng.: *Russell & Axon.*



OLD SETTLING BASINS house these modern Precipitators that boost capacity. North Kansas City, Mo. Cons. Eng.: *C. A. Haskins.*

AWWA ANNUAL CONFERENCE

Atlantic City, N.J. May 12-17, 1957

Official reservation forms have been mailed to all members and are returnable to AWWA postmarked on or after (but not before) noon, Jan. 30.

Coming Meetings

AWWA SECTIONS

Winter-Spring Meetings

Jan. 29—New York Section Midwinter Luncheon, at Park Sheraton Hotel, New York. Secretary, Kimball Blanchard, New York Branch Mgr., Rensselaer Valve Co., c/o Ludlow Valve Co., 11 W. 42nd St., New York.

Feb. 6–8—Indiana Section, at Sheraton-Lincoln Hotel, Indianapolis. Secretary, Robert J. Becker, Supt. of Purif., Indianapolis Water Co., 113 Monument Circle, Indianapolis 6.

Feb. 14—New Jersey Section Midwinter Luncheon, at Hotel Essex House, Newark. Secretary, Albert F. Pleibel, Dist. Sales Mgr., R. D. Wood Co., 683 Prospect St., Maplewood.

Mar. 17–20—Southeastern Section, at Francis Marion Hotel, Charleston, S.C. Secretary, N. M. deJarnette, Engr., Div. of Water Pollution Control, State Dept. of Public Health, 245 State Office Bldg., Atlanta 3, Ga.

Mar. 20–22—Illinois Section, at La-Salle Hotel, Chicago. Secretary, Dewey W. Johnson, Research Engr., Cast Iron Pipe Research Assn., 122 S. Michigan Ave., Chicago 3.

Apr. 4–6—Arizona Section, at Maricopa Inn, Mesa. Secretary, H. C. Bigglestone, Luhrs Tower, Phoenix.

Apr. 5–6—Montana Section, at Rainbow Hotel, Great Falls. Secretary, Arthur W. Clarkson, Acting Chief, Water Sec., Div. of Environmental Sanitation, State Board of Health, Helena.

Apr. 10–12—Kansas Section, at Broadview Hotel, Wichita. Secretary, Harry W. Badley, Repr., Neptune Meter Co., 119 W. Cloud St., Salina.

Apr. 10–12—New York Section, at Mark Twain Hotel, Elmira. Secretary, Kimball Blanchard, New York Branch Mgr., Rensselaer Valve Co., c/o Ludlow Valve Co., 11 W. 42nd St., New York.

Apr. 24–26—Nebraska Section, at Cornhusker Hotel, Lincoln. Secretary, John E. Olsson, 408 Sharp Bldg., Lincoln.

(Continued on page 10)

Coming Meetings

(Continued from page 8)

May 2–4—Pacific Northwest Section, at Winthrop Hotel, Tacoma, Wash. Secretary, Fred D. Jones, Asst. Supt., Water Dept., Rm. 306, City Hall, Spokane, Wash.

Jun. 12–14—Pennsylvania Section, at Bedford Springs Hotel, Bedford Springs. Secretary, L. S. Morgan, Div. Engr., State Dept. of Health, Greensburg.

Jun. 17–19—Canadian Section, at Royal Alexandra Hotel, Winnipeg, Man. Secretary, A. E. Berry, Director, San. Eng. Div., Ontario Dept. of Health, 72 Grenville St., Toronto, Ont.

Fall Meetings

Sep. 4–6—Wisconsin Sec., Milwaukee.

Sep. 11–13—New York Sec., Lake Placid.

Sep. 18–20—Ohio Sec., Cincinnati.

Sep. 23–25—Kentucky-Tennessee Sec., Louisville, Ky.

Sep. 25–27—Michigan Sec., Detroit.

Sep. 25–27—North Central Sec., Fargo, N.D.

Sep. 29–Oct. 1—Missouri Sec., St. Louis.

Oct. 13–16—Southwest Sec., Oklahoma City, Okla.

Oct. 16–18—Iowa Sec., Des Moines.

Oct. 20–23—Alabama-Mississippi Sec., Biloxi, Miss.

Oct. 24–26—New Jersey Sec., Atlantic City.

Oct. 30–Nov. 1—Chesapeake Sec., Washington, D.C.

Oct. 30–Nov. 1—California Sec., San Jose.

Nov. 6–8—Virginia Sec., Roanoke.

Nov. 11–13—North Carolina Sec., Raleigh.

OTHER ORGANIZATIONS

Jan. 17–18—Engineers Joint Council General Assembly, at Statler Hotel, New York, N.Y.

Jan. 23–25—Southeastern Symposium on Industrial Instrumentation, at Univ. of Florida, Gainesville, Fla. Coordinator, W. F. Brown, College of Eng., Gainesville.

Feb. 3–5—Annual Midwinter Conference, Public Utility Buyers' Group, National Assn. of Purchasing Agents, at Brown Hotel, Louisville, Ky. Chairman, L. G. Wiseley, Michigan Consolidated Gas Co., 415 Clifford St., Detroit 26, Mich.

Feb. 15–16—National Society of Professional Engineers, at Hotel Francis Marion, Charleston, S.C.

Feb. 18–22—American Society of Civil Engineers, Jackson, Miss.

Mar. 11–15—2nd EJC Nuclear Engineering Congress & Atomic Exposition, at Convention Hall, Philadelphia, Pa.

Mar. 19–21—American Meteorological Society, at Univ. of Chicago, Chicago, Ill.

Mar. 25–29—Western Metals Congress & Exhibition, at Ambassador Hotel and Pan-Pacific Auditorium, Los Angeles, Calif. Managing Director, W. H. Eisenman, 7301 Euclid Ave., Cleveland 3, Ohio.

Apr. 2–4—Corrosion Control Short Course, at Extension Study Center, Univ. of Oklahoma, Norman, Okla.

Apr. 8–12—American Welding Society, at Hotel Sheraton, Philadelphia, Pa.

Jun. 2–6—Municipal Finance Officers Assn., at Hotel Lowry, St. Paul, Minn.

Jun. 16–21—American Society for Testing Materials, Atlantic City, N.J.

Sparton

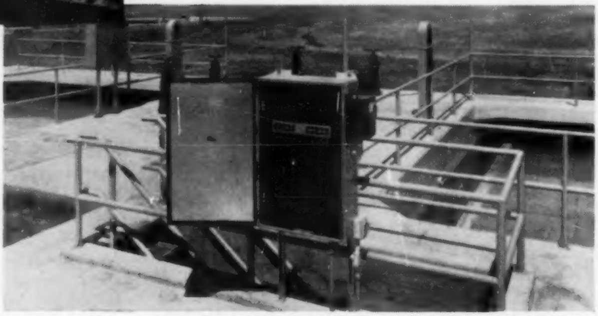
building block control systems

. . . OUTSTANDING ADVANCE IN REMOTE METERING AND CONTROL

To the one-well plant or the giant municipal system, Sparton offers lower control costs, savings in supervisory time, plus flexibility for easy expansion or modification.

Each Sparton system is tailored to requirements through assembly of standard "building block" packages. Sparton techniques, time-proven through years of telegraphy and telephonic communication use, assure reliable, trouble-free service.

STANDARD PLUG-IN MODULES offer variety of control and supervisory techniques—discreet control and supervision with polarized d.c. pulses, time coded d.c. pulses or pulse-time coding; proportional control and supervision with polarized d.c. signals, d.c. pulses or continuous d.c. signals; channel multiplexing by flip-flop, multi-channel scanning or tones.



10-STATION WELL FIELD CONTROL with multi-channel scanning eliminates delays in re-starting remote pumps, minimizes capacity loss due to lightning-induced failures for Kansas system. Control center at treatment plant enables remote control and supervision of each well, plus restart programming. Typical of the many Sparton systems enabling better service at lower cost.

Sparton

Full Story in New Brochure

SPARTON CONTROL SYSTEMS DIVISION JA-1
The Sparks-Withington Company
Jackson, Michigan

Please send waterworks control brochure

Name__________
Title__________
Company__________
Address__________


WALLACE & TIERNAN
V-NOTCH
variable-orifice
CHLORINATORS
A-711 V-notch Chlorinator
has rotameter indicator
with 10 to 1 feed range
A-712 V-notch Chlorinator
has dial indicator with
20 to 1 feed range

Journal

AMERICAN WATER WORKS ASSOCIATION

VOL. 49 • JANUARY 1957 • NO. 1

Effects of Pipe and Tank Lining on Water Quality at Atlanta

Paul Weir

A paper presented on Oct. 17, 1956, at the Southwest Section Meeting, Little Rock, Ark., by Paul Weir, Gen. Mgr., Water Dept., Atlanta, Ga.

THE original paper on the effect of internal pipe lining on water quality was printed in the JOURNAL (*1*) in 1940. This article presents the results of 20 years of continued study in which many of the original tests were extended while additional ones were started to check linings of various mains and elevated storage tanks.

The common effect of ferrous pipelines is to increase the iron content of water, causing it to turn red and stain the plumbing. Waters vary considerably in this tendency. Hard or alkaline waters have little or no tendency to become red, but soft or acid waters attack iron readily. The rate of flow has a pronounced effect on the formation of red water as this determines the period of contact water has with iron. In many systems, only water from slow flowing dead-end mains shows appreciable iron staining.

Linings for ferrous pipes may reduce or prevent some red water formation. Linings, however, may alter the water quality in some way, taste and odor may become noticeable and hardness, alkalinity, or pH may be radically changed. Use of nonferrous piping will eliminate iron stain, but, similarly, desirable water quality characteristics may be altered.

Another adverse effect of interior corrosion on ferrous piping is tuberculation and the subsequent reduction of the flow capacity of the pipeline.

The tests described in this article were started in May 1937, to evaluate the effect of soft Atlanta water on passage through many pipe materials and interior linings. The present tests in Atlanta are focused on water main materials. A 6-in. pipe (Fig. 1, 2a, and 2b), a ¾-in. service pipe (Fig. 2c),

TABLE I

Tap Water Analysis, Atlanta Water Works

Year	Yearly Average*								
	Turbidity	Hardness	CO_2	pH	Fe	O_2 % Saturation	Methyl Orange Alkalinity	Residual Chlor-amine	Tempera-ture—°*F*
1937	0.30	23.5	0	8.5	0.018		23.3	0.25	63.7
1938	0.26	23.4	0	8.5	0.015	92.6	15.4	0.31	65.0
1939	0.27	24.0	0	8.5	0.020	92.1	15.5	0.32	63.4
1940	0.25	24.0	0	8.5	0.025	94.2	15.0	0.38	62.2
1941	0.15	25.2	0	8.5	0.030	96.8	15.3	0.39	63.5
1942	0.10	25.4	0	8.5	0.027	100.1	14.9	0.60	62.9
1943	0.10	29.0	0	8.7	0.023	96.3	15.6	0.69	63.3
1944	0.10	28.2	0	8.7	0.011	96.0	16.3	0.79	62.9
1945	0.10	24.3	0	8.7	0.020	96.5	16.9	0.80	63.5
1946	0.10	24.2	0	8.7	0.018	97.1	15.4	0.77	64.2
1947	0.10	24.2	0	8.7	0.020	94.3	14.8	0.89	63.9
1948	0.10	22.7	0	8.8	0.020	96.2	14.7	0.98	63.9
1949	0.10	22.4	0	8.7	0.020	94.3	16.6	1.00	63.3
1950	0.10	20.2	0	8.7	0.020	94.2	16.4	0.94	63.1
1951	0.10	18.9	0	8.6	0.020	94.1	16.1	0.96	62.8
1952	0.10	19.0	0	8.6	0.010	93.7	16.2	1.0	62.6
1953	0.10	20.3	0	8.7	0.014	91.7	16.2	1.1	64.1
1954	0.10	19.1	0	8.7	0.010	91.8	16.8	1.2	64.7
1955	0.10	18.6	0	8.5	0.011	94.6	18.8	1.1	64.4
19-Year Average	0.138	23.0	0	8.6	0.017	94.8	16.3	0.76	63.5

* Values expressed in ppm except as otherwise noted.

Fig. 1. Test Sections of 6-in. Pipes

A corner of the Atlanta Water Purification Plant where effects of pipe materials and linings are tested.

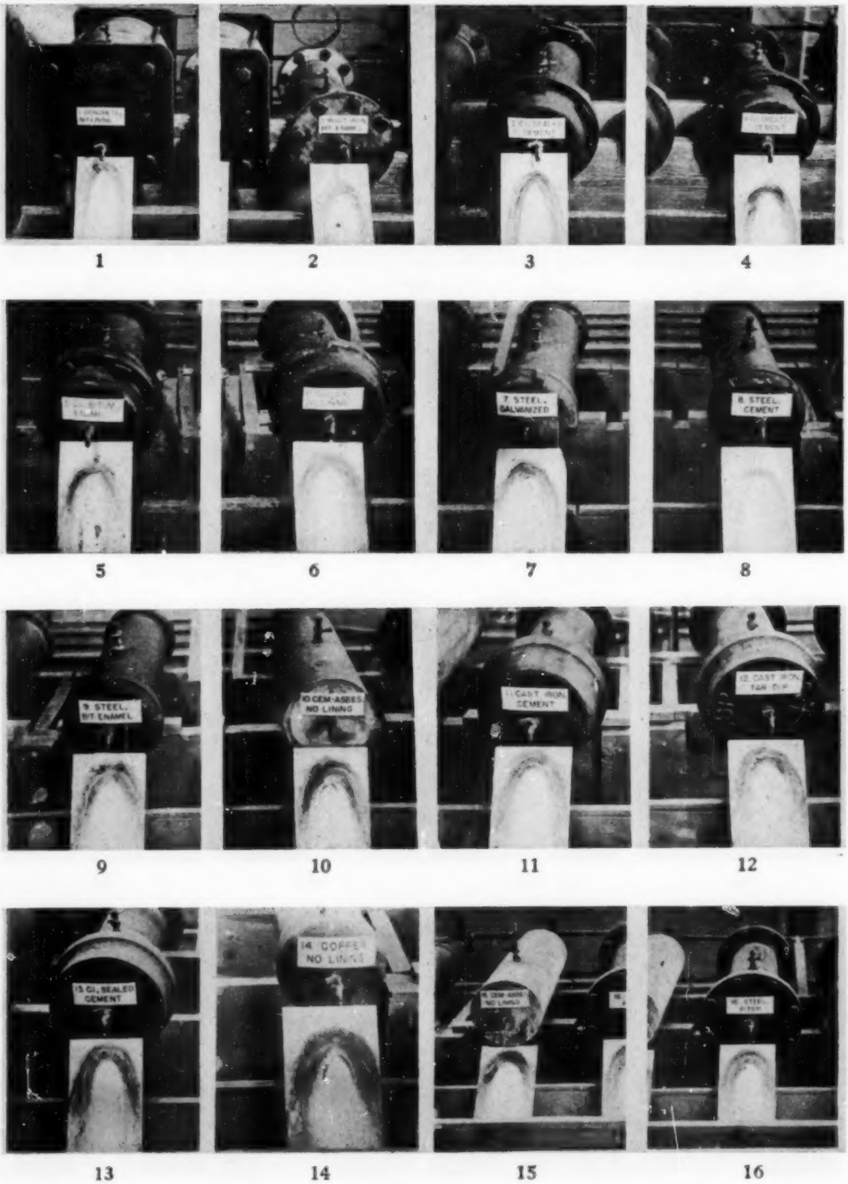


Fig. 2a. Staining of Plates in 6-in. Pipe Tests

A key to the specimen numbers is given in Table 2.

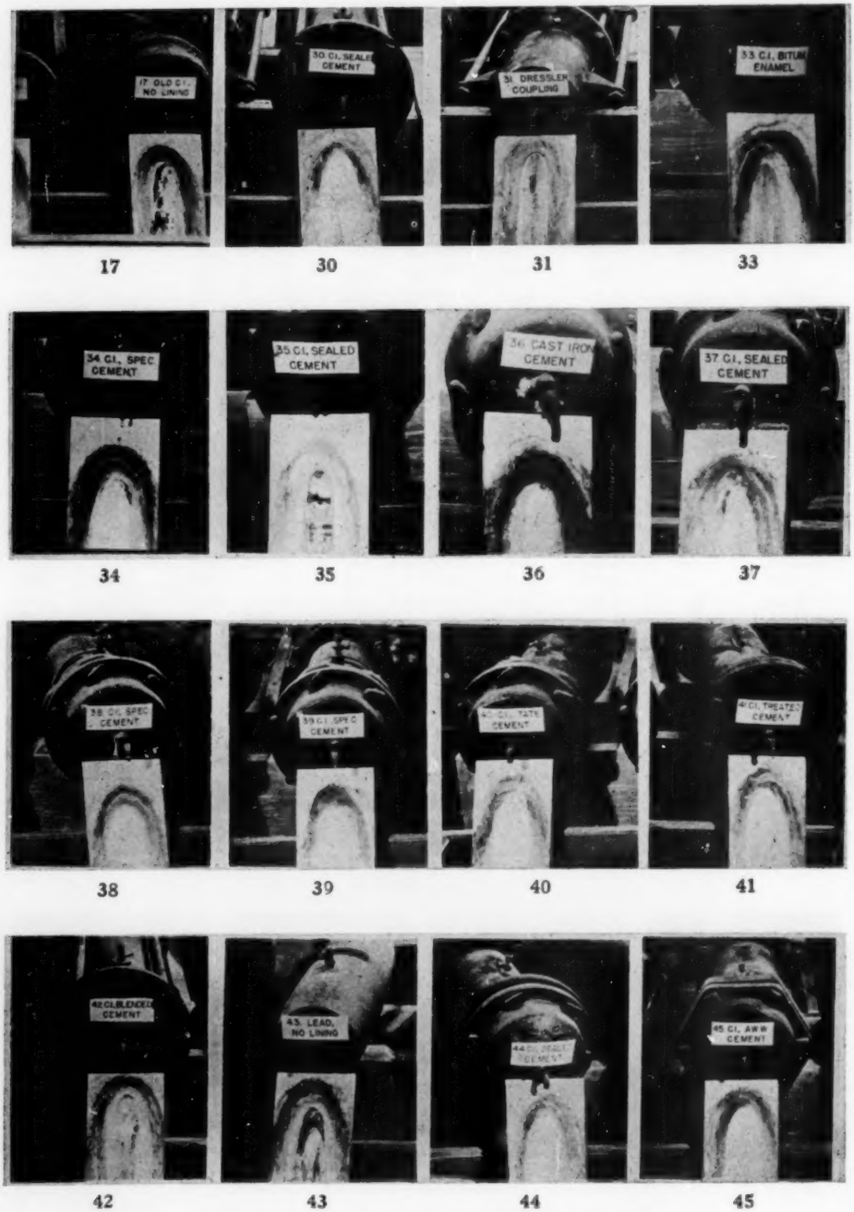
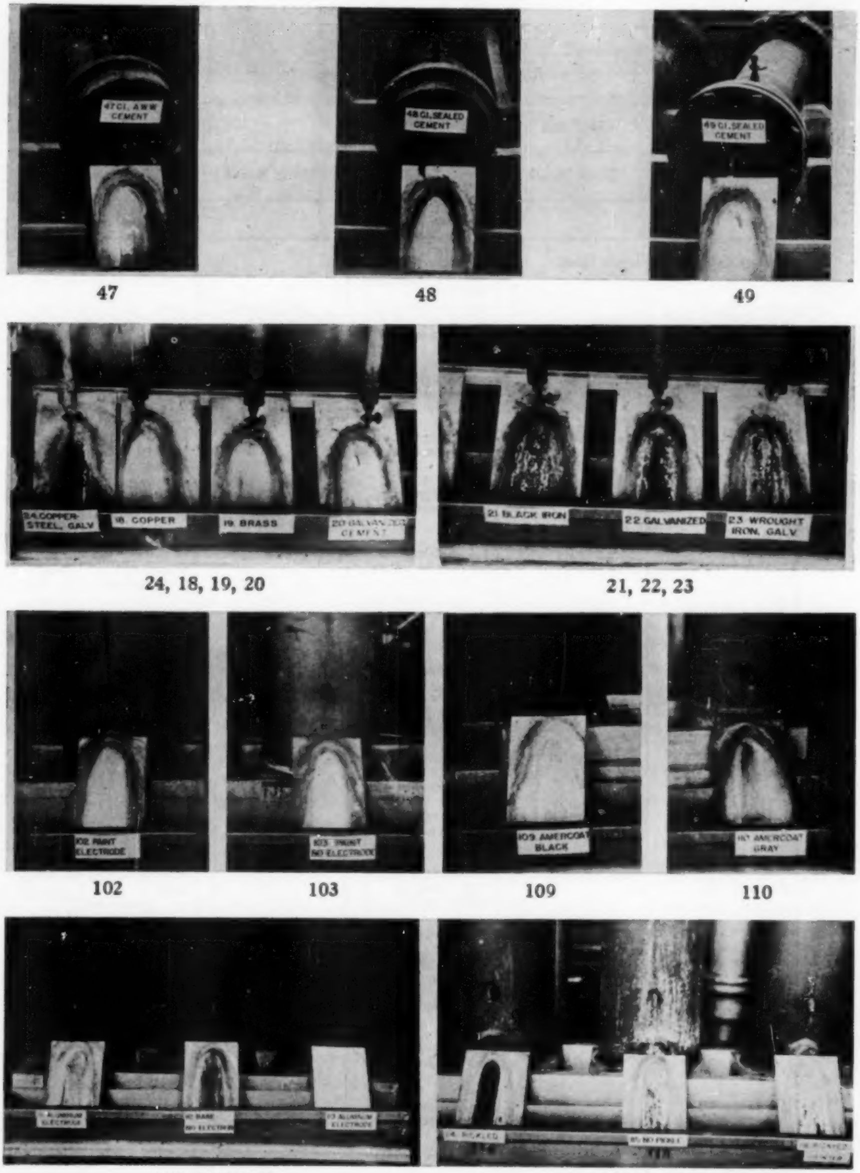


Fig. 2b. Staining of Plates in 6-in. Pipe Tests

A key to the specimen numbers is given in Table 2.



47 48 49

24, 18, 19, 20 21, 22, 23

102 103 109 110

111, 112, 113 114, 115, 116

Fig. 2c. Staining of Plates in Pipe and Elevated Tanks Tests

The top three specimens are 6-in. pipe sections. The specimens second from the top are ¾-in. pipe sections, and the bottom two are elevated tanks. A key to the numbers is given in Table 2.

TABLE 2

Identification of Specimens

Specimen No.	Material			Lining	
	Manufacturer	Trade Name	Type	Trade Name	Type
			6-in. Pipe		
1	Lock-Joint Pipe Co.	Lock-Joint	concrete pipe—steel cylinder reinforced		none
2	Am. Rolling Mill Co.	Armco	spiral welded ingot iron pipe	Wailes-Dove Hermiston No. 70B	spun bitumastic lining
3	Am. Cast Iron Pipe Co.	Mono-Cast	centrifugal cast-iron—cast in sand mold	Enameline	thin cement lining with asphalt seal coat
4	Am. Cast Iron Pipe Co.	Mono-Cast	centrifugal cast-iron—cast in sand mold		thin cement lining treated with sodium silicate
5	Am. Cast Iron Pipe Co.	Mono-Cast	centrifugal cast-iron—cast in sand mold	Barrett Co.	spun bituminous enamel lining
6	Unknown		pit cast-iron in service 20 years		originally tar dip—practically no lining during test
7	National Tube Co.		steel pipe		heavy galvanized
8	National Tube Co.	National Black Duroline Pipe	steel pipe	Duroline	heavy cement lining
9	National Tube Co.		steel pipe	National Bitumastic Cip	bituminous dip lining
10	Johns Manville Co.	Transite	cement-asbestos pipe		none
11	National Cast Iron Pipe Co.	Super de-Lavaud	centrifugal cast-iron—cast in metal molds		standard cement lining
12	U.S. Pipe & Foundry Co.	Super de-Lavaud	centrifugal cast-iron—cast in metal molds		tar dip lining
13	U.S. Pipe & Foundry Co.	Super de-Lavaud	centrifugal cast-iron—cast in metal molds		cement lining tar seal coat
14	Mueller Brass Co.	Streamline	K-copper pipe		none
15	Keabley Mattison Co.	Century Duralite	cement-asbestos pipe		none
16	Youngstown Sheet & Tube Co.		steel pipe	Hill-Hubbell	heavy pitch lining
17	Unknown		pit cast-iron in service for 30 years		originally tar-dipped—practically no lining during test
30	McWane Cast Iron Pipe Co.		statically cast in sand mold		portland cement with asphalt seal coat
31	Dresser Manufacturing Co.	Dresser Coupling	steel		none

TABLE 2 (*Contd*)—*Identification of Specimens*

Specimen No.	Material			Lining	
	Manufacturer	Trade Name	Type	Trade Name	Type
33	U.S. Pipe & Foundry Co.	Super de-Lavaud	centrifugal cast-iron—cast in metal molds	Wales-Dove Hermiston	spun bitumastic enamel lining
34	Am. Cast Iron Pipe Co.	. ono-Cast	centrifugal cast-iron—cast in sand molds		thin cement lining spec. sulfate residual
36	Am. Cast Iron Pipe Co.	Mono-Cast	centrifugal cast-iron—cast in sand molds		standard portland cement lining
37	Am. Cast Iron Pipe Co.	Mono-Cast	centrifugal cast-iron—cast in sand molds	Enameline	thin cement lining with asphalt seal coat
38	Am. Cast Iron Pipe Co.	Mono-Cast	centrifugal cast-iron—cast in sand molds		high alumina cement lining
39	Am. Cast Iron Pipe Co.	Mono-Cast	centrifugal cast-iron—cast in sand molds		modified portland cement lining
40	Unknown		old cast iron cleaned	Tate	cement lined in place
41	R. D. Wood		centrifugal cast in sand mold	HyCO	
42	McWane Cast Iron Pipe Co.		statically cast in sand mold		blended portlandc ement
43	Georgia Lead Company		lead		none
44	U.S. Pipe & Foundry Co.	Super de-Lavaud	centrifugally cast in metal molds		cement lined—seal coat
45	Unknown	Super de-Lavaud	centrifugally cast in metal molds		cement lined by Atlanta water works, seal coated
46	Unknown		cast-iron	No OX-ID	dearborn lined at Atlanta
47	Unknown		cast-iron		cement lined & seal coated by Atlanta water works
48	Lynchburg Foundry Co.		cast-iron		cement lined-seal coated
49	National Cast Iron Pipe Co.	Super de-Lavaud	centrifugal cast-iron—cast in metal molds		thin cement lining with asphalt seal coat
50	National Cast Iron Pipe Co.	Super de-Lavaud	centrifugal cast-iron—cast in metal molds		standard cement lining
			¾-in. Pipe		
18	Mueller Brass Co.	Streamline	K-Copper pipe		none
19	Anaconda Copper Co.	Anaconda 67	yellow brass pipe		none
20	National Tube Co.	Duroline	galvanized steel tubing	Duroline	standard galvanized & cement lining

TABLE 2—(*Contd*)—*Identification of Specimens*

Specimen No.	Material			Lining	
	Manufacturer	Trade Name	Type	Trade Name	Type
21	Jones-Laughlin Steel Co.		black steel tubing		none
22	Youngstown Sheet & Tube Co.		galvanized steel tubing		standard galvanized
23	A. M. Byers	Byers' Genuine W. I. Galvanized Pipe	galvanized wrought-iron pipe		standard galvanized
24	Youngstown Sheet & Tube Co.	Youngstown Copper Old Galv. Tubing	galvanized copper bearing steel tubing		standard galvanized
Elevated Tank Tests					
100	Chicago Bridge and Iron Co.		pickled steel, 10 in.	Carbon Electrode	platinum electrode
101	Chicago Bridge and Iron Co.		10-in. steel, not pickled		combination paint—no electrode
102	R. D. Cole Co.		10-in. steel		segments painted with various paints electrode
103	R. D. Cole Co.		10-in. steel		segments painted with various paints—graphite electrode removed—1943
104			8-in. steel	Wales-Dove-Hermiston Bitumastic 70B	
105			8-in. steel	Flintkote	
106			6-in. cast-iron		bare electrode
107	Truscon Laboratories		No. 1		paint with inhibitor
108	Truscon Laboratories		No. 11		paint
109			8-in. steel	Amercoat	black
110			8-in. steel		electrode removed 1954, Amercoat gray
111			10-in. steel	Rusto Rust Proofing Corp.	electrode removed Nov. 29, 1954 Al. electrode installed Jan. 1, 9155
112			10-in. steel	Rusto Rust Proofing Corp.	bare
113			10-in. steel	Rusto Rust Proofing Corp.	aluminum electrode
114	Chicago Bridge & Iron Co.		pickled complete 8-in steel		paint on outside
115	Chicago Bridge & Iron Co.		8-in. steel		no pickle or paint
116			8-in. steel		pickled and paint

and an 8-in. and 10-in. steel pipe to simulate conditions of elevated water tanks (Fig. 2c), were used in the tests.

The purpose of these tests is to evaluate the efficiency in resisting corrosion and the possible effect on water quality of pipe materials which might be installed in the Atlanta water system. Results of these simple tests provide a reliable guide in selection of pipe material for actual service in the water system.

Test Methods

Purified and filtered water from the Atlanta water system (Table 1), taken at the entrance to the distribution mains, is passed through a pipe specimen under test and allowed to drip from an outlet tap on a white porcelain plate simulating the porcelain sink surface in the home. The detailed arrangement of one 6-in. testing unit is shown in Fig. 3.

As rate of flow and time of contact effect the iron concentration in red water and as red water complaints in the Atlanta system usually originate from dead-end areas, the rates of flow in the tests are made to correspond with that of an average dead-end main, rather than that of a high demand section of the system. The rate of flow adopted was determined by actual tests on dead-end mains and is controlled at 112 drops per minute from the outlet sample tap. At this rate, water passes through the 2-ft long, 6-in. diameter specimens in an average time of 8 hr, and through the $\frac{3}{4}$-in. service pipe specimens 47-ft long in about 3 hr.

The elevated storage tank tests designed to simulate the conditions of an average water tank are filled and emptied on a 12-hr cycle. Sections of 8-in. and 10-in. steel pipe, 2-ft long, and capped on the bottom, are used for these tests. Some of the units have various protective coatings and other units are protected by cathodic application. Thirteen volts are used with platinum and aluminum electrodes in the cathodic protecting.

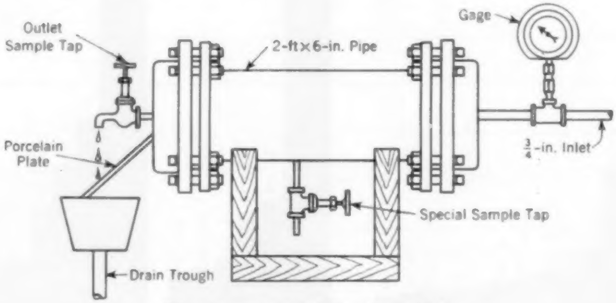


Fig. 3. Typical Testing Unit

The testing unit here shown is for experiments on 6-in. pipe.

There are about 75 test specimens (Table 2), including mains, service lines, and elevated storage tanks. Test results are obtained by examining the staining of the white plates placed under each discharging unit and by comparing effluent water analyses from each unit with the purified influent water. Each specimen is sampled at least once a month. Analyses and tests of each sample are made to determine turbidity, color, hardness, temperature, CO_2, pH, iron, total alkalinity, dissolved oxygen, residual chloramine,

phenolphthalein alkalinity, and total solids.

Four types of stains are identified by this test: [1] red staining of the white porcelain plates under test units—most direct method of measuring solution of iron from pipe sections; [2] leaching of alkali from cement in the case of concrete, cement-asbestos, or cement-lined pipe causing a dark gray stain; [3] dezincification of galvanized pipe causing a dull metallic stain; and [4] the additional, unavoidable faint gray halo on each plate regardless of the specimen caused by atmospheric dust.

Data Obtained

The analytical data accumulating from monthly tests are gathered into yearly averages. These have been used in this report for comparing tap water with the water from the various units.

Water quality is affected in its passage through the pipe. The percentage of oxygen consumed was determined by subtracting the average oxygen content of the effluent from the influent tap water oxygen content for the entire test period. This value is useful as it indicates the corroding tendency of a material; most normal corrosion processes are in direct proportion to the amount of oxygen used.

The iron content of the effluent is another useful analytical value used to indicate the relative corrosion of ferrous piping or the effectiveness of the ferrous pipe lining. It is certainly the analytical value which best indicates pipe tendencies to cause red water stains.

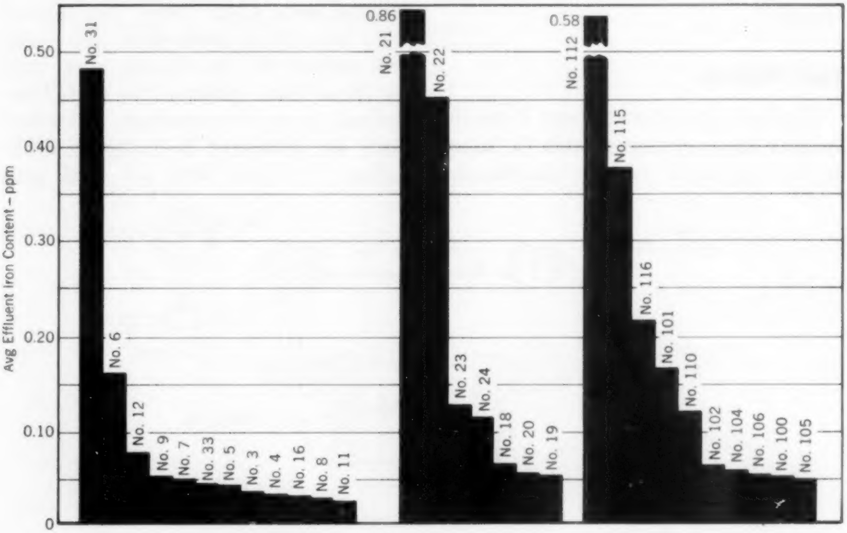


Fig. 4. Average Iron Content Effects Over Entire Test Period

The averages shown on the left refer to 6-in. pipe specimens. The tests were taken over a 19-year period. The center averages are those of ¾-in. pipes over the same period. Elevated tanks, shown on the right, were tested over a 15-year period. All specimen numbers are decoded in Table 2.

In a cement pipe, the degree of attack on the cement is best evaluated by considering pH, hardness, and alkalinity increases during passage through the section.

Analysis of Data

The data on the effluent water analysis from the various test units were studied. Some of the water quality factors that showed a change are presented graphically in this article.

The average iron content of several representative tests is shown in Fig. 4. Unlined or bare pipe tests were included to indicate the effectiveness of the protective linings. The length of time that the specimens were under test is indicated. The iron content is the average for the entire test period.

A comparison of the yearly iron analysis for various cast-iron specimens is shown in Fig. 5. The amount of iron corrosion in the unprotected pipe wall diminished after a few years, but the seal coated cement lining afforded the best protection.

The iron contents of the effluent water from the elevated tank specimens are compared in Fig. 6. With the exception of the bare, unprotected steel specimen, most of the tests showed about the same amount of iron pickup after being in service for 7 years.

The reduction in oxygen content of water passing through a pipe is a useful measure of the corroding tendency of the pipe. Figure 7 shows the rating of most of the test specimens according to the percentage of oxygen consumed. These values were determined by subtracting the average effluent water oxygen content of each specimen for the entire test period from the average oxygen content of the tap water for the same period. A comparison be-

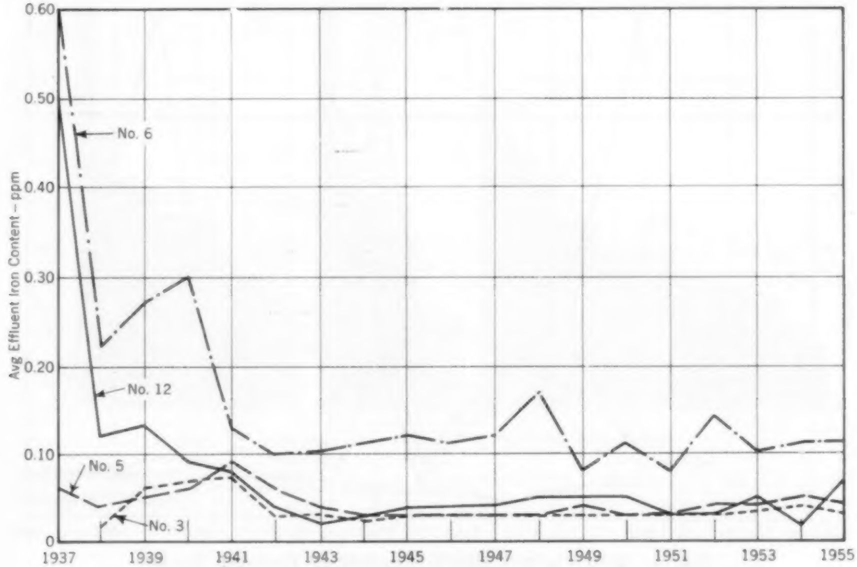


Fig. 5. Iron Content Yearly Average of 6-in. Pipe Specimens

A key to pipe numbers is given in Table 2.

tween Fig. 4 and Fig. 7 shows a correlation between the oxygen consumed and the iron pickup in the water.

Unless protected by a seal coat, pipes made or lined with cement tend to increase the hardness of the water. The effects of three kinds of pipe on water hardness are shown in Fig. 8. In the concrete and cement-asbestos, hardness increase is high for the first few years, but then diminishes. Concrete pipe induces the most water hardness; cement-asbestos next, and cement-lined and seal coated cast-iron shows the smallest amount of hardness pickup.

A rapid method of checking effectiveness of the seal coat protection in the cement lining is to cut a 2-ft section from the spigot end of a pipe selected from each shipment of pipe received. One end of this specimen is imbedded in molten paraffin in a pie tin and the section is filled with water. A plate glass cover is placed on the top of the test section and the water is sampled and analyzed on 3 successive days. If water reaches the cement, it will leach it and increase the hardness.

After new water mains are installed, the water is checked periodically until it is stabilized.

Conclusions

It has been estimated that 1 year in these corrosion tests is equivalent to 5 years of field service. Conclusions drawn from these tests apply only to the units tested and to the particular water in the Atlanta system. The results may, however, give some indication of how the various pipe materials will function in a system distributing this or any similar water.

Following are the tentative conclusions drawn from the results of six test

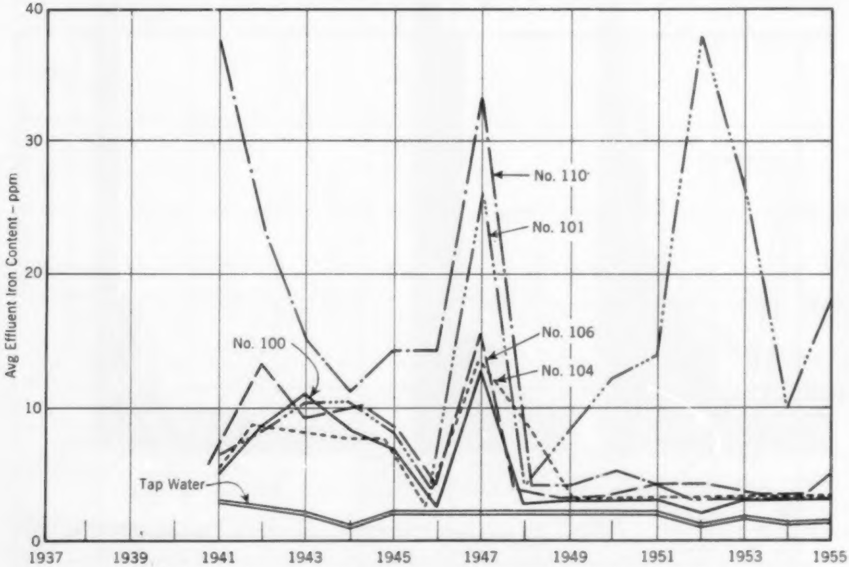


Fig. 6. Iron Content Yearly Average of Elevated Tanks

A key to all specimens numbered is given in Table 2.

units representing many different products:

1. Bare or unlined ferrous pipe shows sufficient internal corrosion by Atlanta water to cause tuberculation and stains where the rate of flow is low. The iron pickup seems to diminish appreciably after a few years.

2. All linings that were tested reduced the internal corrosion. The tar-dip lining gave little protection the first 2 or 3 years, but then gave better results (Fig. 5).

3. Pipe made of concrete, cement-asbestos, or lined with cement, showed less staining in most cases, but hardness, alkalinity, and pH of the water increased unless the cement was protected by seal coating (Fig. 8).

4. Bituminous enamel or pitch linings did not cause increase in hardness or alkalinity and, when of good quality, reduce the tendency of the water to stain.

5. In elevated tank tests, protective coatings and use of electrodes lowered the corroding tendency of water (Fig. 6).

6. Galvanizing, particularly of service pipe, is of considerable value in preventing iron corrosion of the pipe.

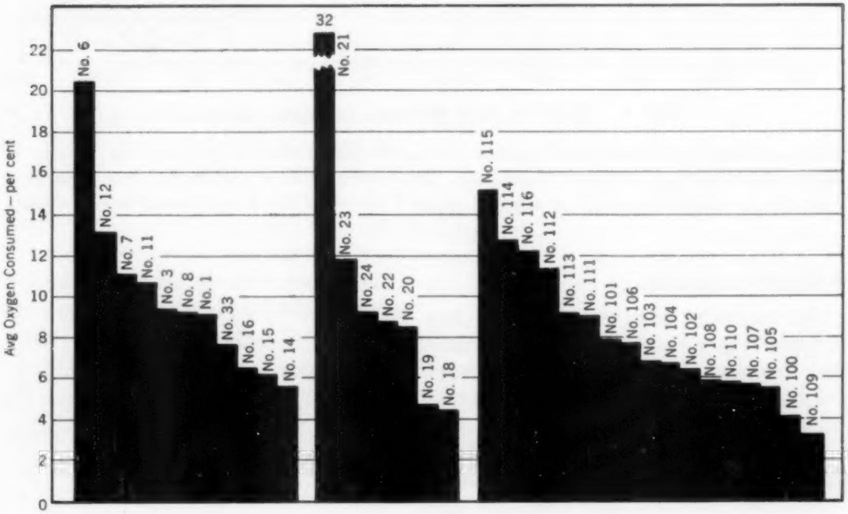


Fig. 7. Average Percentage of Oxygen Consumed

Oxygen consumption is a useful measure of the corroding tendency of a pipe or tank. The averages shown on the left are those of 6-in. pipes; those in the center of ¾-in. pipe; and those on the right of elevated tanks. Table 2 gives further details on the numbered specimens used.

7. Nonferrous metallic pipes such as those made of copper, brass, or aluminum alloy, show little or no attack by this water.

8. Short-period tests conducted at the River Pumping Station substantiated the fact that protection against corrosion was better effected by cement-lined cast-iron pipe than by the tar dipped specimens.

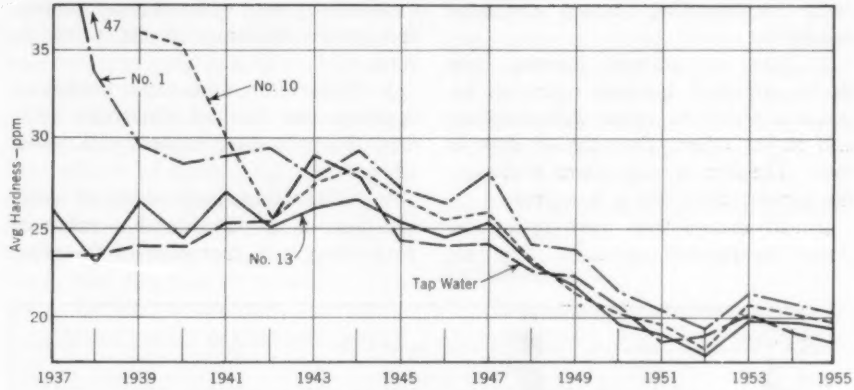


Fig. 8. Effect of Pipe Material on Water Hardness

Three types of 6-in. pipes were tested over a 19-year period to discover the effects of material and lining on water hardness. The cement lined and sealed cast-iron pipe (No. 13) showed the smallest amount of pick up. All three specimens are described in Table 2.

Acknowledgments

This work is being carried on at the Atlanta Water Purification Plant under the direction of Sherman Russell, Superintendent, and A. T. Storey, Director of Laboratories.

Sincere appreciation is expressed to Clyde D. Wood, Research Chemist, American Cast Iron Pipe Company, to all pipe manufacturers who collaborated, and others who furnished material and suggestions for this work.

The author is grateful for the interest manifested in this important research project by William B. Hartsfield, Mayor of Atlanta, and James E. Jackson, Chairman, Water Committee, Board of Alderman, Atlanta, Georgia.

Reference

1. WEIR, PAUL. The Effects of Internal Pipe Lining on Water Quality. *Jour. AWWA*, **32**:1547 (Sep. 1940).

The McIlroy Fluid Analyzer in Water Works Practice

—— Victor A. Appleyard and Frank P. Linaweaver Jr. ——

A combination of papers presented on Apr. 4, 1956, at the Pennsylvania Section Meeting, Philadelphia, Pa., by Victor A. Appleyard, Chief, Water Operation, Philadelphia, Pa., and on Oct. 26, 1955, at the Chesapeake Section Meeting, by Frank P. Linaweaver Jr., Junior Civil Engr., Bureau of Water Supply, Baltimore, Md. The original discussions followed the installation of McIllroy Analyzers at Philadelphia and Baltimore in the fall of 1955.

RAPID growth in suburban areas and a corresponding increase in water consumption have brought about the need for the extension of water distribution systems throughout the country. With the enormous expenditures involved, careful planning and economical design are obviously necessary. Until recently, the engineer responsible for the study of flow and pressure distribution in a complex pipeline network, relied entirely on tedious, time-consuming computations in developing the system design. A new analysis was required for every new construction or operation proposal. Today, the many hours of laborious computations can be replaced by the use of a unique analog computer—the McIlroy Fluid Network Analyzer (*1*), devised by the late Malcolm S. McIlroy, Professor of Electrical Engineering at Cornell University. This machine enables the engineer to analyze a water distribution system by using an analogous electrical circuit. The analyzer thus becomes a working model made up of the usual impressive assemblies of electrical components commonly associated with electronic brains.

History

The original idea of an electric pipeline network analyzer was conceived in about 1932 by H. L. Hazen, then Assistant Professor of Electrical Engineering at M.I.T. Hazen mentioned the idea to Thomas R. Camp, Associate Professor of Sanitary Engineering and, together, they developed the idea, reporting their findings late in 1934 (*2*). The electric resistor was, at that time, used to represent a pipeline, and it obviously was quite inaccurate.

In 1943, Camp published another article on this same subject (*3*) pointing out that the Hardy-Cross method and the Aldrich graphical methods of analysis had been developed in 1936. Vacuum tubes were used in 1942 and, in the following year, some time was spent in trying to develop a tube that would act electrically exactly as a pipeline does hydraulically.

World War II interrupted this basic research, and it was not until the end of it that McIlroy, then on the staff of M.I.T., decided to concentrate on the solution of this problem. Having solved the vacuum tube design problem, he went on to design the complete analyzer.

McIlroy received his doctor's degree from M.I.T. with a thesis on the research and development of the analyzer. He went to Cornell University in 1948 and, under a research grant, completed his first model. The care and patience which he had lavished on this project induced a heart condition which caused his untimely death at the age of 53.

Although this article discusses the analyzer only in connection with water systems, it also can be used for analysis of any type of fluid distribution systems such as gas, oil, or air conditioning. Analyzers are being used by large oil companies, the US Bureau of Mines, and a group of midwestern consultants. The first two water works departments to purchase analyzers were the cities of Baltimore, Md., and Philadelphia, Pa. The control panel of the Philadelphia unit is shown in Fig. 1.

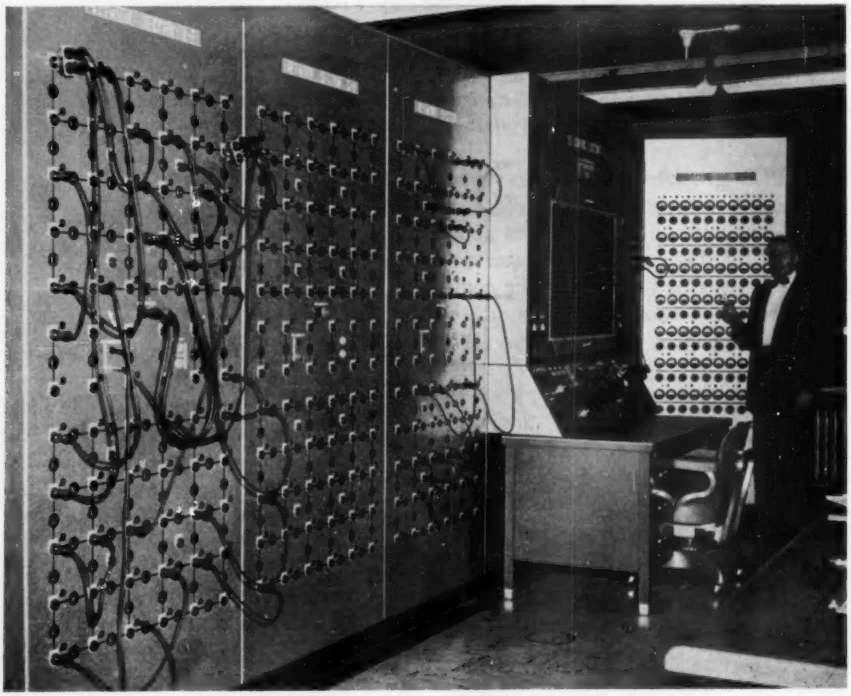


Fig. 1. Control Panel of the McIlroy Analyzer

The panel of the control section serves to connect all other sections of the analyzer. The one shown here was installed in Philadelphia.

Analogies

The analysis of a pipeline network is based on five analogies which exist between hydraulic and electrical characteristics. The first is that the flow of water, Q, in a pipeline behaves in

the same manner as the flow of current, I, in an electric circuit.

The second is that the friction head loss, H, resulting from the flow of water in a pipeline is analogous to the voltage drop, V, caused by the flow of current in a resistor.

The third analogy is expressed by the law that the total flow of water approaching any junction equals the total flow leaving it (See Fig. 2 where $Q_1 = Q_2 + Q_3$). In an electrical circuit, the sum of the currents approaching any junction equals the sum of the currents leaving it $(I_1 = I_2 + I_3)$.

The fourth analogy is expressed by the law that the sum of the clockwise head losses around any loop in a pipe network equals the sum of the counterclockwise head losses around that loop $(H_2 + H_4 = H_3 + H_5)$. In an electrical circuit, the sum of the clockwise voltage drops bounding any loop equals the sum of the counterclockwise voltage drops around that loop $(V_2 + V_4 = V_3 + V_5)$.

The fifth analogy is a result of the development of a special nonlinear resistor which is the electrical equivalent of a pipeline in a water distribution system. In a pipeline, the head loss varies nearly as the square of the flow, or $H = k_p\ Q^{1.85}$ where k_p represents the pipe dimensions and roughness coefficient (Hazen-Williams formula). To obtain direct solutions from an electrical circuit, the voltage drop must vary nearly as the square of the current, or $V = k\ I^{1.85}$ where k is called the coefficient of the resistor and is analogous to k_p, the head loss coefficient of a pipeline. In this equation V and I have a nonlinear relationship. The voltage drop in an ordinary electrical circuit is directly proportional to the current, or $V = RI$ where the resistance, R, is a constant. Thus, ordinarily, V and I have a linear relationship.

Description

Basically, the analyzer has four sections—the network, the load, the source, and the control.

The network section which duplicates the pipeline system, is made up of a series of plug jacks and socket panels. Each pipeline is represented by a fluistor * (Fig. 3) which consists of a tungsten filament supported on heavy nickel leads contained within an evacuated glass bulb. The heart of this analyzer is the fluistor which, when direct current is passed through it, acts exactly like a pipeline. As the current passing through the tungsten filament increases, the filament becomes hotter and its resistance increases. By designing the filament and leads to suitable dimensions, the voltage drop can be made to vary at the desired exponential function of the current $(V = k\ \ I^{1.85})$. One must know the length, size, and Hazen-Williams roughness coefficient of the pipeline in order to compute the equivalent pipe in the form of the fluistor. It is easy to connect the fluistors electrically to duplicate pipelines in the distribution system. The analyzer in Fig. 1 has sockets for 312 pipelines.

In the source section, the direct current is fed into the network of fluistors exactly as the flow of water enters the pipeline system under study. Sources such as pumping stations and reservoirs are represented on the analyzer by rheostats fed by direct current from a motor-driven generator. Known differences of head between

* The fluistor is manufactured by the Standard Electric Time Company, Springfield, Mass.

sources are maintained by adjusting the rheostats to the desired differences of source voltages. The Philadelphia analyzer shown in Fig. 1 has a capacity of eleven sources.

The load section consists of electronic circuits which duplicate the amount of flow from the system under study. Loads, or take-offs from a water system, usually occur randomly along the pipes, but their equivalent may be represented by concentrated loads connected at the pipeline junctions. The electronic circuits control the desired constant discharges from the pipeline network, regardless of the voltages (pressures) available. The Philadelphia analyzer has a capacity of 73 loads.

The control section connects all other sections. Master meters are used to read all the values of flow and head loss. The starting, stopping, and other controls are also on this panel.

Operation

The analyzer is extremely accurate in the answers it produces. It is obvious, however, that the answers are only as accurate as the field data that are fed into the machine. The characteristics of every pipeline involved must be ascertained in the field. A schematic diagram of the pipeline network should first be prepared. The k_p values, which represent the pipe dimensions and roughness coefficients, are calculated and placed opposite each pipe in the network. The various loads are assigned to their respective network intersection. There are two

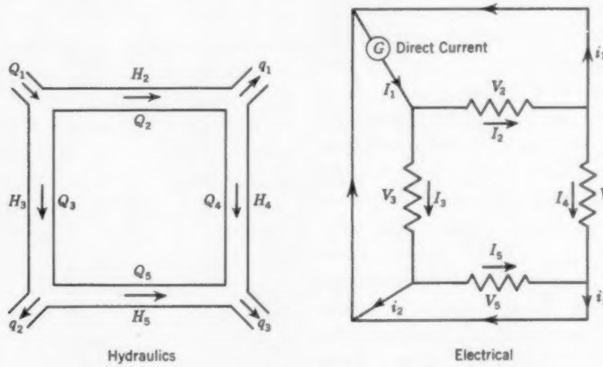


Fig. 2. Hydraulic and Electrical Analogies

The five analogies are as follows (the symbols are explained in the text):

$$Q \sim I \quad\ldots\ldots (1)$$
$$H \sim V \quad\ldots\ldots (2)$$
$$Q_1 = Q_2 + Q_3 \quad\ldots\ldots (3)$$
$$I_1 = I_2 + I_3$$
$$H_2 + H_4 = H_3 + H_5 \quad\ldots\ldots (4)$$
$$V_2 + V_4 = V_3 + V_5$$
$$H = K_pQ^{1.85} \quad\ldots\ldots (5)$$
$$V = KI^{1.85}$$

ways of taking into account the conditions at the sources: known or estimated available heads at reservoirs and pumping stations can be used to determine the related flows at the respective inputs; known or estimated rates of flow into the network can be used to determine the heads at the sources.

The conversion factors needed to translate hydraulic quantities to electrical quantities are then selected so that the average voltage drop (head loss) per fluistor (pipeline) is about 2.5 v. An electrical circuit diagram arranged exactly as the pipeline network map is then prepared showing the k values for the pipes and all the necessary data in electrical quantities.

Fig. 3. Network Section Fluistor

Each fluistor represents a pipeline in the system.

The fluistors, with coefficient values as close as possible to the values of k given in the circuit diagram, are then inserted in the proper sockets. If all of a certain k value have been utilized and another is desired, combinations of fluistors in series or in parallel may be used. The network panels are connected to the source panel and the electronic load devices are inserted at the proper network intersections by flexible jumper cords. After all connections have been completed, the analyzer is energized by gradually raising the power supply voltage. While the voltage is being increased, the operator watches the fluistor filaments, and replaces those that tend to glow too brightly with an equivalent combination of fluistors in series.

All fluistors are designed to operate normally over the same range of voltage (0–4.6 v.), and at any given voltage, all their filaments glow at nearly the same brightness. Since head loss is proportional to voltage, the fluistors having the brightest filaments correspond to the pipelines which have the largest head losses in the network. Thus, the operator immediately knows the portions of the distribution system needing strengthening. If desired, a new pipeline may be added to the analysis as soon as a weak spot in the distribution system is noted. This simply involves calculating the representative value of k and placing the fluistor on the analyzer.

When all specified source and load conditions are satisfied, the desired values of head losses and flow rates are read on the control panel from the master voltmeter and ammeter respectively. Calibrated demountable scales are provided so that the readings are taken directly in hydraulic terms. The results are recorded on a pipe network diagram. Alternate conditions of operation can easily be studied by changing the values of the sources and loads on the analyzer.

The time involved in making a complete analysis of a water distribution system is amazingly short. Two engineers can analyze the flows and pressure drops in a system with 50 pipelines, three sources, and twenty loads in half a working day, including the time involved in setting up the analyzer. Many alternative conditions of operation such as peak flows, average

flows, and reservoir-filling conditions can be analyzed during the remaining part of the day. This is a very small fraction of the time involved to do the same analyses by the ordinary methods.

Typical Applications

The McIlroy Fluid Network Analyzer can be used for the solution of many of the problems which confront water works engineers. Once the pipe system has been set up, the loads can be varied to fit any conditions desired. If the estimated load conditions in 1980 were applied to the system, for example, the pressure available at any exact location could be easily determined. If a large fire demand were applied at a specific point in the distribution system, the pressure available to the fire department under the high load conditions could be easily determined. Many more such possibilities can be postulated. Other tasks which the analyzer is capable of reaching include:

1. Locating the source of operating difficulties or bottlenecks in existing water systems
2. Checking assumed roughness coefficients by correlating analyzer results with actual field measurements of flow rates and pressures
3. Determining conditions under which a line or a portion of a line may be safely removed from service for cleaning and cement lining, or for extensive repairs
4. Studying the operational cycle of a water system having multiple distribution reservoirs
5. Evaluating pressure variations due to change in loads
6. Determining the hydraulic information required for preparation of constant-pressure contour maps
7. Determining available fire flows throughout the system under various consumption rates
8. Selecting new pipeline diameters for best combinations of economy and performance
9. Determining the best location for new pipelines
10. Determining the best elevation and location of reservoirs or storage tanks
11. Selecting pump ratings
12. Studying plans of operation in case of major failure to any part of the water works system.

Thus, the McIlroy Fluid Network Analyzer arms engineers with thorough and economical methods of design, and consequently makes possible better service at lower cost.

References

1. McILROY, MALCOM S. Direct Reading Electric Analyser for Pipeline Network. *Jour. AWWA*, **42**:347 (Apr. 1950).
2. CAMP, THOMAS R. & HAZEN, HAROLD L. Hydraulic Analysis of Water Distribution Systems by Means of an Electric Network Analyzer. *J. NEWWA*, **48**:383 (Dec. 1934).
3. CAMP, THOMAS R. Hydraulics of Distribution Systems—Some Recent Developments in Methods of Analysis. *J. NEWWA*, **57**:334 (Dec. 1943).

Records and Accounts for Small Systems

Jess L. Haley

A paper presented on Oct. 22, 1956, at the Alabama-Mississippi Section Meeting, Mobile, Ala., by Jess L. Haley, Supt., Public Utilities Com., Water & Light Dept., Clarksdale, Miss.

RECORDS can generally be classified as financial and statistical. Statistical records are those dealing with operational details such as water pumped and sold, new services connected, and pipes laid. Financial records deal with the handling of money and investment.

Managers usually carry a good deal of statistical information in their heads, so that a wealth of good data are buried when a water superintendent passes on. Yet it is indisputable that a piece of paper can contain and record information more accurately than the human mind. Keeping too many records, however, can become a handicap when servicemen take a full hour each day to complete paper work. While it is true that an accounting system is no better than the original record of the serviceman, it is also true that a system can be designed to have simple records, thus allowing servicemen to devote more time to their other duties.

An accounting system must be able to give accurate, up-to-the-moment information that includes the many factors which do not reoccur every month, such as depreciation, insurance, taxes, and stocks. Accrual accounting is contrasted with cash accounting in this respect, as the former attempts to take into account items other than necessary cash affecting business.

A checkbook can sometimes serve as the only accounting record of a small business. Much valuable data, however, will fail to be recorded.

The following example will show the value of accrual accounting. A man purchases a $2,500 automobile to use as a taxi, counting on a $50 a week or better salary in his venture. Given the premise that the man is not ambitious and does not plan to draw more than $2,600 a year as salary, his yearly expense will be as shown in Table 1. It will be noted that all items listed are cash items with the exception of depreciation. If the owner takes in a total of $4,500 in a year, he has actually lost money because he could have invested that same $2,500 at 4 per cent interest, and earned at least $100 a year. If this amount is not exceeded, therefore, the owner would have done better to hire someone at $50 a week, thus freeing his time for other work. If the income from the business were $5,000 a year, he would then be in about as good a position as if he had invested his $2,500 in government bonds and had worked for a salary of $50 a week for someone else. One other factor involved in the expense should be noted. The depreciation is shown as $500 a year; a shrewd businessman will put his money aside every year, so that, at the end of 4 years, he will have enough to buy a new piece of equipment.

This is a simple illustration which

is true for large as well as small businesses.

Statistical Information

Any manager of a water utility must have certain minimum information to run his business wisely. Statistically, he needs to know or have on hand the following:

1. Amount of water pumped into the system
2. Amount of water sold to the customers
3. Consumer habits and characteristics
4. Rate of increase in number of customers
5. System losses
6. System maps.

Other statistical records needed include such things as delivery capabilities of the system at various points (to know weak and strong points when planning extensions), and relation of supply to demand. These two items are more the concern of operations and so will not be further considered in this article.

TABLE 1
Yearly Expenses for Taxi

Item	Amount—$
Salary	2,600
Gas and oil	875
Taxes and licenses	200
Repairs	200
Depreciation*	500
Miscellaneous	125
Total	4,500

* Estimating useful life of automobile at not more than 5 years.

Statistical records giving the preceding information can be tabulated and charted to give an accurate estimate of future trends. A monthly chart of water pumped and sold presents a picture that cannot possibly be kept in one's head for a continuing period of years. Furthermore, a "12-month" curve will eliminate seasonal fluctuations and present a clear picture of growth.

System losses are another factor that a manager must keep in mind. In a distribution system, losses exceeding 15 per cent are serious. A system consistently showing a 25–30 per cent loss will have about 9–10 per cent revenue loss.

Financial Information

Financial records that are necessary to the manager are:

1. Proper valuation of the system
2. Depreciation of the system
3. Operating expenses
4. Reinvestments in new capital improvements
5. Cash position
6. Long term debt.

These items can be further divided. The system evaluation, for example, can be divided into investments in mains, meters, services, and storage and supply equipment.

Interpretation of detailed operating expenses vary greatly according to the individual manager, although there are certain standards in any business. Recommended as a guide is the *Manual of Water Works Accounting* (*1*), which, in spite of its rather detailed coverage, can be very useful to the small system operator. This system is patterned after the uniform system of accounts as required by the Federal Power Commission for all private utilities under their jurisdiction.

Developing a System

In developing an accounting system for a small utility, the first step should be to gather statistical data from old records of pumping, sales, revenue,

available maps of the system and these should then be tabulated by months as far back as possible, then gathered into yearly periods which are plotted on graphs. An analysis of these graphs would reveal whether the system is growing, remaining steady or going backward. If such charts are kept constantly up to date, it becomes possible to forecast future trends.

If system maps are not available, a map of the community on a scale of at least 100 ft to the inch should be obtained. With the cooperation of the servicemen, an accurate system map should be built up. A pipe locator will be invaluable in the process of constructing system maps and will pay for itself in a very short time. The maps should include the exact location of lines, size of mains, and location of valves. As the system becomes more familiar, detection of weaknesses becomes easier, and planning can be started on making extensions or ties between mains. At intersections where more details are needed, enlarged scales permit all information to be accurately charted. This information will become invaluable in times of trouble, for guesswork under pressure seldom gives good results.

TABLE 2

Clarksdale, Miss., Yearly Depreciation Estimates

Section of Water Works System	Amount of Depreciation in Percentage of Total Cost
Reservoir	2
Pumping equipment	4
Treatment equipment	10
Distribution mains and accessories	1½
Fire hydrants	2
Services	3½
Meters	4
Transportation equipment	12
Wells	4

In areas of universal metering, all those receiving water should be checked to see that they have meters. This can be done only on a door-to-door basis, and will often bring a number of surprises to light.

Once system maps are available, a system evaluation must be made. This is simply the total valuation of all items carried on the inventory.

The next step is to determine the depreciation of the system. Once the age of the various sections is determined, a formula such as the one used in Clarksdale (Table 2) can be used. The yearly depreciation can be broken down into monthly costs and included in monthly reports.

Acquiring Financial Records

Once a nucleus of statistical information has been developed, the next step is to draw together a set of financial records. If the only records available are bank deposits and checkbook stubs, the latter should be carefully analyzed for the preceding 2 years. This is a fairly simple piece of accounting that can be done by any intelligent man with a high school education, and that will reveal a number of facts about the operation of the system. A typical disbursement analysis is shown in Table 3.

Control of revenue collection must be established. A manager is not fulfilling his responsibilities until he sets up a system to make sure that the service bills are being paid. This means that a list of customers and amounts of their bills must be made, and that a note of the payment must be made for each customer. This will bring to light all delinquent bills. Most utilities indicate that a bill rendered on the first of the month is due by the

TABLE 3

Typical Monthly Disbursement Analysis

Ck. No.	Name	Total $	Operating Expense		Stock		Capital		Other	
			Item	Amount $	Item	Amount $	Item	Amount $	Item	Amount $
1	Power Utility Co.	225	pumping	225						
2	Printing Co.	25	stationery	25						
3	Well Co.	300	well repair	300						
4	Meter Co.	50			meters*	50				
5	Pipe Co.	200			pipe†	200				
6	Post Office	10	stamps	10						
7	Sam Doaks	125	labor	100			1st St.‡	25		
8	Mary Jones	75	clerk	75						
9	Inv. Co.	1,150	interest	150					bonds	1,000
10	Joe Jones	200	supt.	200						
11	Service Station	25	trucking	25						
12	Home Insurance Co.	240							insurance‖	240
13	City	500							general fund	500
14	Joe Doaks	125	labor	50			10th St.§	75		
15	Mary Jones	75	clerk	75						
16	Joe Jones	200	supt.	200						
	Totals	3,525		1,435		250		100		1,740

* Two $\frac{5}{8}$-in. meters.
† 400 ft of 2-in. pipe.
‡ Two-inch line extension.
§ Six-inch line.
‖ Prepaid.

tenth, and with the provision that if not paid by the twentieth, service will be cut off. Once this practice has been established no customers should be granted special favors.

When this point in acquiring records is reached, it is a good time to estimate how much more needs to be done. Water works usually keep a supply of pipes, valves and other equipment and materials on hand, and no accounting record is complete until these inventories are taken into consideration. A system of making receipts, checking invoices, and checking material before invoices are paid should be followed.

If possible, a time sheet report should be kept for all employees. A daily time report on a sheet designed to show what work is actually accomplished each day, not only will help to complete the records, but will also help employees understand the need to be productive. It is true that this record can be falsified by employees, but sooner or later, this will come to light, especially in a small community if the manager is awake. Time sheet reports may very often not be necessary. It is not normal, for example, to ask a clerk whose time is spent on the same thing every day to fill out a report card.

Conclusion

After a records system has been developed, it will be wise to compare operations with other utilities of about the same size. A wide difference in meter reading costs, for instance, might suggest an investigation to uncover hidden defects. In this manner a company can profit by the experience of others.

The benefits derived from statistics would be greatly increased if all water utilities in a section produced records that were consistent. Small utilities might use simplified systems patterned on those of the larger firms.

The ultimate aim of any accounting and record system is to give all reasonable information without overdoing the amount of paper work involved. The primary work of an accounting system is to produce information for the management, and not to ease the work of the accountant.

Translating operating results into terms usable by management can be accomplished in even the smallest operations. Outlines of three important types of financial statements are given in the appendix.

Reference

1. *Manual of Water Works Accounting.* Municipal Finance Officers Assn. & Amer. Water Wks. Assn., New York, N.Y. (1938).

APPENDIX

Detailed Cost Breakdown

A detailed cost breakdown is calculated for the total yearly production. Each of the following items is expressed in cents per million gallon as well as total cost for the year.

Production Costs
- Water pumping labor
- Water pumping electricity
- Other production expense
- Depreciation
- Insurance
- Interest
- Allocated administrative expense
  - *Total production costs*

Distribution Costs
- Operating expense
- Maintenance
- Depreciation
- Insurance
- Interest
- Stores expense
  - *Total distribution costs*

Other Operating Costs
- Customer accounting and collecting
- Administrative and general
  - *Total other operating costs*
    - *Total all costs*

Total Water Revenue
Net Income to Surplus

Statement of Operating Expenses

The following operating expenses are tabulated for both monthly periods and the year to date.

Production Expense
- Operation supervision
- City water pumping labor
- Miscellaneous station labor
- City water pumping, electricity, and fuel
- Station expenses
- Maintenance of structures and improvements
- Maintenance of city wells
- Employees welfare and expense—plant
- Treatment labor
- Treatment supplies and expense
- Maintenance of structures and improvements
- Maintenance of treatment equipment
  - *Total*

Distribution Expense
- Operation supervision and engineering
- Operation of lines
- Services on customer premises
- Street repairs, labor and material
- Maintenance of mains
- Maintenance of valves and equipment
- Maintenance of services
- Maintenance of meters
- Employees welfare and expense—district
  - *Total*

Customers Accounts and Collecting
- Customers contracts meter reading
- Customers billing and accounting
  - *Total*

Administrative and General Expense
- Sales promotion expense
- Sales general, officers and executives
- Other general office salaries
- Expense of general office salaries
- General office supplies and expense
- Special services
- Legal services
- Insurance
- Miscellaneous general expense
- Maintenance of general property
- Rent
- Rent on office equipment
- Stores expense
  - *Total*

Profit or Loss Statement

The profit or lost statement features, in addition to the following items, figures on the number of customers served by the utility, and the amount of water pumped, sold, and lost. The number of customers for that month is compared to the number for the same month in the previous year. The amount of water pumped, sold, and lost is tabulated for that month, for the year to date, and for the 12 previous months to date. The net profit or loss is drawn up for that month and the year to date.

Operating Revenue
- Water sales
- Water for city
- Interdepartmental sales—plant use
  - Total
- Water taps
- Service charges
- Miscellaneous revenue
  - Total operating revenue less charges for water for city
  - *Net operating revenue*

Operating Expense
- Production expense
- Distribution expense
- Customer collection and accounting
- Administrative and general
  - *Total*
- Depreciation
  - *Total operating expense*
  - *Net operating profit*

Other Expense
- Bond interest expense
- Interest on contracts

Services to City
- Labor and material—fire hydrants
- Other services to city
  - *Total*

Net Profit or Loss

Correction

The paper "MF Techniques in Quality Control" by Harold A. Thomas Jr., Richard L. Woodward, and Paul W. Kabler (November 1956 Journal, Vol. 48, pp. 1391–1402), contained several editorial errors. The word "cooperative" in the footnote on p. 1393 should be changed to "comparative." The italic note under Fig. 2 on p. 1398 mentions "80 or more colonies." This should have read: "8 or more colonies." On p. 1401, Eq 4, which reads "$0.1 \geq \sum_{x=0}^{5} x\,P(x)$", should have read "$0.1 \geq \frac{1}{5} \sum_{x=0}^{5} x\,P(x)$".

Changing Concepts of Water Quality

Jack E. McKee

A paper presented on Oct. 24, 1956, at the California Section Meeting, San Diego, Calif., by Jack E. McKee, Prof. of San. Eng., California Inst. of Technology, Pasadena, Calif.

CHANGE is inevitable, whether it pertains to women's fashions, popular music, the philosophy of education, or the imperceptible weathering of the Pyramids. Concepts are particularly susceptible to change, for they constitute an integration of the ideas, thoughts, and notions produced by alterations in our environment and the increasing desires or demands of life. Sometimes these concepts change slowly, as exemplified by certain religions, or rapidly, as demonstrated by mass hysteria in wars and riots, but change they must. Often changes in concepts are so gradual and subtle that they are not recognized soon enough by the proper authorities.

Like all concepts, those relating to the physical, chemical, and biological qualities of water are subject to modification. The public water supply profession is obliged to recognize these changes, to assess them properly, and to determine how they may affect the planning, design, and operation of water works. Failure to do so promptly and effectively may seriously retard the progress of water supply and treatment.

Concepts of water quality are divided logically into two major categories. One relates to the sources of raw water and the other to the quality of water delivered to the user, whether domestic or industrial. Each category is considered separately in the following discussion in order to emphasize certain aspects and trends, but it must be recognized that the two categories are intimately interrelated. The primary aims of this paper are to describe the widening gap between these categories, to discuss its implications to the water works profession, and to predict its probable effect on the planning, design, and operation of water supply facilities.

Influences on Raw Water

Pristine, indeed, are the waters unaffected in any manner by the presence and activities of man. Rare though they may be, such waters are not immune from changes in quality. Erosion and other natural processes of weathering produce silt and turbidity in varying degrees. Extended periods of wet and dry years alter the characteristics of streams in relatively short periods while long-time trends have lasting effects on surface waters and ground water basins. Certainly, then, even a pristine source on a "protected watershed" can be expected to change in quality from year to year.

Man's impact on a natural water course may be exerted in various ways and in many degrees. First to consider, perhaps, is the development of natural resources. Deforestation of the virgin trees and reforestation with a new species may alter the quality of surface drainage and ground water by

changing the forest ground cover, by decreasing transpiration, and by increasing evaporation. The uncontrolled development of mineral and petroleum resources may result in gross pollution of surface streams and underground basins, as it occurs in hydraulic mining, by acid mine drainage, and by the discharge of oil field brines. Even the harnessing of water power by the impoundment of surface streams will have an effect on the quality of the water.

Agriculture represents a second major impact on water quality. Even in the absence of irrigation, the cultivation of land affects the quality of surface and subsurface waters. When irrigation is practiced, these effects are generally intensified. Natural return flow or artificial drainage from irrigated fields will contain dissolved minerals in excess of those in the applied water, the type and magnitude of such increases being a function of the crops grown, irrigation practice, climate, soil characteristics, and similar factors. If an area were to develop solely with an intensive agrarian economy, the quality of its waters would certainly change markedly.

The growth of agriculture and the development of natural resources lead to concentrations of population and the water-carriage system of waste disposal, the third major impact. Fortunately, the practice of discharging raw sewage, without treatment, is rapidly diminishing. It must be recognized, however, that no practical degree of treatment will restore used domestic water to its original quality. Even with complete biological stabilization, the total dissolved solids may be expected to increase by 100 to 300 mg/l, corresponding to about 70 lb per capita per year (*1, 2*). Despite this increase, there are instances where treated waste waters may be superior in quality to alternate sources of supply. For this reason, reclaimed waste waters should always be considered as one of the potential sources of fresh water in arid regions.

A minor factor in the quality of raw-water sources, but one that cannot be ignored, is the demand for and the effect of recreational use of surface waters. When fresh-water streams and lakes are limited, as they are throughout much of California, they cannot forever be denied to the public for fishing, boating, and even swimming. In the past, many cities have relied upon protection of watersheds to preclude the need for treatment in excess of chlorination. Such protection, at best, is risky and difficult to enforce. Cities must face the changing concept of watershed protection, share the limited facilities for recreational purposes, and be prepared to extend the degree of water treatment. This does not mean, of course, that open distribution reservoirs or other impoundments close to the consumer should be exposed to contamination by recreational use. Somewhere between the concept of completely protected watersheds and that of contaminated distribution reservoirs rests the equitable solution to this problem.

Finally, liquid wastes from certain industrial processes may exert a tremendous effect upon water resources. The number, variety, and character of such wastes are too complex to describe here. Of significance, however, is the fact that these wastes are highly variable from industry to industry, and from period to period at the same plant. The development of new processes and the synthesis of novel compounds require that water pollution control authorities be constantly alert to the hazards of new waste waters.

Fluoride complexes, hydrazine compounds, acrylic acid derivatives, and radioactive materials are but a few of the substances whose disposal constitutes industrial-waste problems. Certainly, change is the order of the times.

The net effect of man's multifaceted impact has been, and will continue to be, a deterioration of the quality of natural fresh-water resources, whether surface or underground. This is a concept that all must recognize and face. The trend is inevitable as long as population continues to increase and industrialization is intensified. The trend can be combatted and perhaps slowed by rigid control of industrial wastes, by regulation of resources development, and by treatment of municipal wastes, but it cannot be stopped or reversed and its ultimate development cannot be prevented unless the industrial and agricultural development of this nation is to be curtailed. Allowance must be made in our water works planning for this eventual impairment.

In California today, the impact looms especially ominous, for there the combined rate of increase of population, industry, and agriculture is probably greater than in any other state. Compounding the problem are the arid nature of much of the area and the consequent high value of water. The situation is not unique to California or the West, however, for humid areas are also beginning to experience deterioration in water quality as a result of newly instituted irrigation. Eastern states, moreover, have long faced the impact of municipal and industrial pollution. The problems and principles are the same in the East and the West. Only the magnitude and imminence are different. In conjunction with this inevitable and irreversible deterioration of the sources of raw water, it is of value to examine trends in the needs and demands of water users.

Criteria for Finished Water

Man's original criteria of water quality were simple indeed; they consisted largely of physical tests such as temperature, taste, odor, color, and turbidity. Although old and familiar to the layman, these criteria scarcely deserve the faith placed in them by a Mississippi jurist in 1904 when he ruled, in part, "It is not necessary to weigh with tenderness and care the testimony of experts. Any ordinary mortal knows whether water is fit to drink and use" (*3*). In another instance (*4*), the appellate court declared, "Indeed, it seems that the trial judge subjected the question to 'trial by water' because the record discloses that his Honor 'had drunk of the water, bathed in it, and suffered no ill effects.' "

Chemical criteria of water quality were proposed almost two centuries ago. Early observers, for example, viewed organic matter in water with suspicion. They attempted to determine it quantitatively and relate it to the incidence of disease. That human and animal wastes could contaminate water and render it dangerous has been known for centuries, but not until after van Leeuwenhoek developed the microscopy of water were bacterial and biological yardsticks formulated.

Criteria and analyses of water quality have progressed remarkably in the past century and even in the past two decades. This progress is described by Wolman (*5*), Hinman (*6*), Thresh and Beale (*7*), Baker (*8*), McKee (*9*), and others. Perhaps the best and most recent evidence of the inevitable change in our requirements for water quality is the Drinking Water Stand-

ards of the US Public Health Service. Supplementary are the various editions of *Standard Methods* (*10*). The fact that these standards and the methods of analysis are revised and improved every 5 to 10 years is ample proof of our progress in water quality criteria. Each change is attributable to advanced knowledge of the effects of various substances on the many beneficial uses of water.

Not all changes are in the direction of stricter standards. Some of the earlier requirements were unduly restrictive because the thresholds of toxicity or other detrimental effects were unknown. The interim standards, as a result, reflected a conservative approach. As research unfolded the true effects, however, these conservative standards were relaxed. In 1942, for example, the USPHS Drinking Water Standards restricted copper to 0.3 mg/l and hexavalent chromium to 0.00 mg/l. By 1946 these requirements had been relaxed to 3 mg/l for copper and 0.05 mg/l for hexavalent chromium. The next revision may see further liberalization of standards.

New Trends

Our concepts of the quality requirements for finished waters appear to be shaped by several trends. First, as the standard of living rises and the "luxury" market expands, there is a continuing pressure for water of the highest possible quality. Modern Americans demand the finest. For this reason, imperfections in treated water delivered to consumers are seldom tolerated, especially by the housewife. Silt in the laundry tub or automatic washing machine, iron or manganese stains on the porcelain of the wash basin, discolorations in a pitcher of water, or a ring around the bathtub are frowned upon by modern Americans who expect, and rightfully demand, the highest possible quality.

This trend in the luxury market is illustrated by the increasing popularity of household water softeners, despite a frequently heard contention that the new synthetic detergents (syndets) make softening unnecessary. Syndets are used extensively for dishwashing and home laundries, but they have not replaced soap in the bathtub, shower, or washbasin, where the hardness of water becomes most evident to the user. Soft water is still a luxury much desired by housewives for washing hair, skin, and nylon fabrics. Indeed, many commercial laundries and restaurants still favor soft water and soap over synthetic detergents for washing clothes and dishes.

The second trend that may alter our concepts of finished water is the demand for additives to improve the quality of water for a specific purpose. Illustrative of this trend is the campaign by dental and public health authorities for fluoridation of water to supplement our fluoride-deficient diets. The municipal water supply has been designated by American public health agencies as the chosen vehicle to deliver approximately 1 mg of fluoride per day to each child. In some countries, with less haste and more scientific rationalization, other vehicles are being considered (*11*).

Fluoride and, formerly, iodide are but the first of many trace elements that may be added to water. It is not difficult to envision traces of cobalt or copper that might improve bone structure or skin. Perhaps 0.5 mg/l of boron could be added to make grass grow better on watered lawns. Indeed, the day may not be distant when odor-masking or deodorant compounds are added to improve the taste of water. Certainly, a slight peppermint

taste would be preferable to that of dilute hydrocarbons. Truly, the role of trace substances represents a new frontier of American life, and the water supply may be chosen as the vehicle to deliver some of these substances to every household.

Another trend that will shape thoughts about the quality of finished water is the increasing proportion of municipal water supplies being used by industry. Several cities can be cited where the population is declining but total water use is skyrocketing as a result of the demands by industry. Water works engineers must give increasing attention to the primary need of industry for water of a quality that remains relatively constant over reasonable periods of time. Most industries are willing to accept municipal water that meets drinking water standards, with the recognition that this water must be altered for specific industrial purposes such as boiler feed, cooling, or process water. Industry is quite prepared to accept and further treat municipal water, provided that such water is not subject to sudden changes in quality.

Where a municipal supply is drawn from several sources of different quality, the water works superintendent should take care to avoid switching the source that serves an industrial area. Such sudden changes in water quality may upset the predetermined treatment for cooling water or for water that enters the manufactured product. Brewing processes, for example, are particularly sensitive to changes in water quality, especially if nitrates are involved. To assure industry of a relatively constant water quality, it may be necessary to redesign a distribution system to enable various sources of raw water to be blended uniformly.

Finally, concepts of finished water are being shaped by improved methods of analysis. Where once the water chemist relied on simple physical and chemical tests, he now has at his disposal equipment such as the flame photometer or, perhaps, even the infrared spectrophotometer to measure trace elements, the new molecular-filter membrane techniques for bacterial assay, adsorptive devices such as the carbon filter for microanalysis of odoriferous compounds, liquid- and gas-chromatographic procedures, and several other recent improvements. While many of these techniques are still confined to research laboratories, their impact will soon be felt in water works practice. Most important, perhaps, is the trend toward electronic instrumentation to provide continuous analyses and graphic records of water quality. Here the water works engineer has much to learn from equipment manufacturers and from other branches of engineering and science.

To epitomize these trends and concepts in the quality of finished water, it is apparent that consumers, both domestic and industrial, will continue to demand improved quality and greater uniformity. To meet these requirements, the water works operator must start with sources of raw water that are likely to deteriorate in future years. He must, therefore, produce a better and more uniform product on the one hand while drawing upon a poorer source of supply. Fortunately, he can call upon many recent improvements in technology that are capable of bridging the widening gap in quality between raw and finished waters.

Significance

With the changing concepts of water quality in raw and finished supplies

recognized, it is logical to inquire how these changes will affect the planning, design, and operation of water works. Perhaps it is not too early to formulate plans and take action to meet these challenges.

For water works everywhere, the major inference is clear—namely, that a better and more uniform finished water must be produced from deteriorating and variable sources of supply. Corollary inferences can be drawn for any specific geographical area, based on the peculiarities of local situations. In California, for example, the water works profession must recognize and plan for the following changing concepts:

1. Quality is equally as important as quantity in meeting the future water requirements of each region in California. Recognized and propounded by Harvey O. Banks, Director of the new Department of Water Resources (*12*), this concept need not be elaborated here. It is gratifying to note that, unlike the Colorado River Compact of several decades ago, the new California Water Plan will embrace quality control as well as quantity considerations.

2. The quality of raw-water resources is bound, inevitably, to decline as the density of population, industry, agriculture, and recreation increases. Fortunately, however, the pollution and contamination of these waters can be kept within acceptable limits by vigilant and resourceful control measures. To do so, the state and regional water pollution control boards of California must formulate and adopt long-range plans and policies. Moreover, there must be a close interrelationship of these programs, especially where water is to be transferred from one basin to another, as visualized in the California Water Plan.

3. Ground water resources demand equal recognition with surface waters in plans for water quality. The degradation and pollution of ground water are difficult to detect and predict. By the time they are fully recognized and evaluated, moreover, they may have progressed so far that they cannot be reversed readily. For these reasons it is essential to have a complete program of ground water monitoring, comparable in scope and intensity to the present monitoring program for surface waters.

The recycling of water through a ground water basin by the extensive use of well water is analogous to the circulation of water in a cooling tower. Makeup water is needed to replace the evaporative losses in a cooling tower, but unless the makeup water is as chemically pure as that lost by evaporation, salts will accumulate in the system. To maintain an acceptable salt concentration in the recirculated water, a "bleed" valve must be provided. In a similar manner, heavily developed ground water basins must have a bleed valve to maintain acceptable salt balances. The bleed valve for many areas will take the form of a trunk sewer to carry municipal and industrial wastes to the ocean.

4. For some areas, the reclamation and reutilization of waste waters may become a feasible and, indeed, necessary part of the overall water economy. Even when cycled through ground water basins or diluted with surface water, such reutilization will require strict controls for water quality. For reduction in the total dissolved solids of reclaimed water, the new electrolytic methods involving ion-permeable membranes show promise of economic feasibility.

5. To meet the demands of domestic and industrial consumers for water of

superior quality and greater uniformity, improved treatment methods are indicated. Cities with no treatment other than chlorination might well consider the desirability of constructing modern facilities to meet these increasing demands.

6. Finally, water works chemists and bacteriologists must keep abreast of the rapid progress in techniques of analysis and quality control, with special attention to instrumentation for continuous recording of water quality.

Summary

The growth of population, expansion of industry, intensification of agriculture, and increasing demands for recreational use of surface waters all point to further impairment of the quality of the sources of municipal water supply. In contrast, the domestic and industrial consumers of finished water are demanding improved quality and greater uniformity. To meet these exacting requirements with poorer sources of supply, the water works profession must plan for better treatment and closer control of quality. Fortunately, recent advances in technology and analytical methods will facilitate higher degrees of treatment and control. Water works authorities are obliged to keep abreast of these available improvements and to plan accordingly.

Problems of water quality are especially acute in California where the impacts of population, industry, and agriculture are aggravated by the arid nature of much of the state. In the new California Water Plan, involving the transfer of water from regions of excess to areas of shortage, quality as well as quantity must be considered. Indeed, quality may well be the controlling factor in many significant decisions.

References

1. *Studies of Waste Water Reclamation and Utilization.* California State Water Pollution Control Board, Publication No. 9 (1954).
2. HILL, RAYMOND A. Population Growth vs. Water Quality. A paper presented before the California State Chamber of Commerce Conference on Water Quality, San Francisco (May 24, 1956).
3. MASON, WILLIAM P. *Examination of Water (Chemical and Bacteriological).* John Wiley and Sons, New York (1908).
4. *Town of Smithfield* v. *City of Raleigh* (1935, 207 No. Carolina 597, 178 S. E. 144).
5. WOLMAN, ABEL. 75 Years of Improvement in Water Supply Quality. *Jour. AWWA,* **48**:905 (Aug. 1956).
6. HINMAN, JACK J., JR. Standards of Quality of Water. *Jour. AWWA,* **7**:821 (Jul. 1920).
7. THRESH, J. C. & BEALE, J. F. *The Examination of Waters and Water Supplies.* P. Blakiston's Sons & Co., Philadelphia (3rd ed., 1925).
8. BAKER, M. N. *The Quest for Pure Water.* Am. Wtr. Wks. Assn., New York, N. Y. (1948).
9. MCKEE, J. E. *Water Quality Criteria.* California State Water Pollution Control Board, Publication No. 3 (1952).
10. *Standard Methods for the Examination of Water, Sewage, and Industrial Wastes.* APHA, AWWA & FSIWA, New York (10th ed., 1955).
11. ZIEGLER, EUGEN. Untersuchungen Ueber die Fluorierung der Milch zur Caries-prophylaxe. *Mitt. Naturw. Ges. in Winterthur,* Heft 28 (1956).
12. BANKS, HARVEY O. Quality vs. Quantity in Meeting California's Future Water Needs. A paper presented before the California State Chamber of Commerce Conference on Water Quality, San Francisco (May 24, 1956).

Fluorspar for Fluoridation

Franz J. Maier and Ervin Bellack

A paper presented on Oct. 26, 1956, at the Chesapeake Section Meeting, Baltimore, Md., by Franz J. Maier, San. Engr. Director, and Ervin Bellack, Chemist, Div. of Dental Public Health, USPHS, Bethesda, Md.

THE principal items of cost in fluoridating public water supplies are the chemicals, the feeding equipment, and labor; of these, the chemical costs are by far the greatest. Consequently, if the cost of chemicals were reduced, the fluoridation procedure would be an even smaller factor economically. The greatest reduction of such costs can be achieved by using fluorspar, the cheapest of all commercial fluorides. The least costly fluoride compound now being used for fluoridation, sodium silicofluoride, costs three times as much as fluorspar.

Except for the silicofluorides, which are obtained as a byproduct of the phosphate industry, fluorspar is the basic raw material for all other compounds containing fluoride. Fluorspar is a nonmetallic mineral which contains a sufficient amount of fluorite (CaF_2) to make it commercially valuable. Fluorite contains 51.1 per cent calcium and 48.9 per cent fluorine. Industrial grades of fluorspar, prepared for the consumer, normally contain from 85 to more than 98 per cent fluorite. The untreated ores may contain as little as 30 per cent fluorite which must be increased by methods appropriate to the ultimate use of the fluorspar. Fluorite is a lustrous, glasslike mineral, generally translucent to transparent. It may be clear and colorless, or range in color from blue to violet, amethyst, purple-green, and yellow. It commonly occurs in masses of very pure crystalline material, and is found with calcite, barite, quartz, and galena, from which it must be separated. The largest deposits are found in sedimentary rocks at shallow depths.

Occurrence

Fluorspar occurs on every continent, and there is substantial commercial production in Argentina, Australia, Canada, China, Korea, England, France, Germany, Italy, Mexico, Newfoundland, Russia, Spain, Tunisia, Union of South Africa, and the United States. The largest deposits so far discovered are in southern Illinois and northwestern Kentucky, where the fluorspar area covers about 700 square miles. Colorado and New Mexico are the principal Western States producing fluorspar.

The first recorded use of fluorspar in the United States occurred in 1823 when a small amount from Shawneetown, Ill., was mixed with sulfuric acid to produce hydrofluoric acid. While the value of fluorspar as a flux was known in 1529, it was not until 1837 that some fluorspar mined near Trumball, Conn., was used in the United States with iron pyrite in the smelting of copper ores. Production was low until the value of fluorspar as

a flux in the production of open-hearth steel was discovered. Imports and domestic production rose to over 300,000 tons per year prior to World War II. Since then, normal consumption has averaged about 500,000 tons per year.

Fluorspar ore, as mined, is generally intermixed with many other rocks which must be separated from it before commercial distribution. The methods of separation are standard ore-dressing techniques, including washing, screening, gravity separation by jigs and tables, and flotation. Some processes are very simple, involving only crushing and screening—as in the preparation of fluorspar as a flux for steel making—or very complicated—as in preparing it for use in ceramics or acid making (*1*).

Fluorspar must be high in calcium fluoride and low in silica for manufacture of hydrofluoric acid and fluoride compounds. Very little fluorspar can meet the specifications for chemical grade material without special purification processes—usually flotation. A typical process of such ore beneficiation would be as follows: The ore is fed through a crushing system to reduce the size to about $\frac{3}{8}$–$1\frac{1}{2}$. A ball mill, in conjunction with a cross-flow or spiral classifier, reduces this size to between 35 and 200 mesh. Most ores require the removal of zinc or lead sulfides by flotation. Soda ash is added to the flotation circuit to hold the pH at 8.5–10. Other reagents usually include a frother, oleic acid (for collector purposes), and quebracho (a calcite depressor). Three to seven cleanings or "passes" are required to produce acid grade fluorspar. Final flotation concentrate is pumped to a thickener from which the pulp (50–60 per cent solids) is pumped to a rotary-drum filter. The filter cake goes to a rotary dryer which reduces moisture content to 1 per cent (*2*).

Commercial Fluorspar

Three principal grades of fluorspar are commercially available. Metallurgical fluorspar for steel making (55 per cent of the total) should contain about 85 per cent fluorite and not more than 5 per cent silica. Acid grade (about 28 per cent of the total) is usually at least 98 per cent fluorite and less than 1 per cent silica. The ceramic grade (an intermediate one) requires about a 95 per cent purity with no more than 2.5 per cent silica. At the present time, the respective fob domestic-mines prices are \$38, \$48 and \$43 per ton (*3*). The present minimum cost of fluoridation (using sodium silicofluoride) is three times what it would be if fluorspar, at \$40 per ton, were used.

In 1950 it was suggested that calcium fluoride, being the cheapest commercial source of fluoride, could be used to advantage in larger water plants where it might be fed directly into the water (*4*). Acting on this information, at least one water plant contemplated using calcium fluoride and completed a series of experiments to determine the behavior of the compound in practice (*5*). It was found that the handbook value for fluorspar solubility (0.0016 per cent) was very misleading. Much of the material was not even wetted by water (because of the action of the flotation reagents), much less dissolved. Further experiments showed that a large excess of calcium fluoride, in the form of fluorspar previously calcined, plus violent stirring and long retention time, were necessary before even a 1-mg/l fluoride

solution could be obtained. It was apparent that some means of putting calcium fluoride into solution was needed before the economic advantage of its use could be realized.

Although fluorspar has very low solubility in water, "it is slightly soluble in cold, strong acids and quite readily soluble in solution of aluminum salts" (*6*). This gave two possibilities for achieving solutions of calcium fluoride in a practicable manner. The first, dissolving in acid, was quickly ruled out because the amount of the cheapest strong acid (sulfuric acid) necessary to dissolve the fluorspar would raise the cost of the resulting fluoride solution to that of sodium silicofluoride and, in addition, would complicate the preparation of the solution in a water plant. The second possibility, a solution of aluminum salts, is much more practical, because one of the more commonly used chemicals in water plants is filter alum.

In a laboratory experiment, weighed amounts of finely ground fluorspar were added to alum solutions of varying concentrations. The mixtures were stirred and samples of supernatant liquid were withdrawn regularly for fluoride analysis. After 24 hr, no further quantities of fluorspar were dissolved, and the fluoride ion concentration approximated 0.1 of the alum concentration. In other words, a 10 per cent alum solution contained 1 per cent fluoride, or 10,000 mg/l as F^-. The same ratio held for the range of 1–30 per cent alum, giving fluoride-ion concentrations of 1,000 to 30,000 mg/l.

It was found later that with an excess of fluorspar present, and with vigorous stirring, saturated fluoride solution of strengths proportional to the alum concentrations could be obtained in 2 hr. This was much more practicable and led the way to the development of a dissolver.

Model Dissolver

The first workable model of the dissolver consisted of a round, cone-bottomed glass container with an inverted glass funnel suspended within. A stirring paddle which rotated in the center of the funnel was driven by a vertical shaft inserted through the stem of the funnel. The funnel and the cone bottom provided a means for stilling and contact similar to that of sludge blanket type softening and clarification equipment. With this arrangement, practically all the undissolved solids remained in the cone, while the alum solution passed downward through the funnel stem, dissolved the fluorspar, and rose around the outside of the funnel as a clear solution saturated with fluoride ion.

The placement of the funnel relative to the stirring paddle proved to be critical, as was the design of the paddle itself. With the paddle considerably below the funnel, solids were circulated all the way to the top of the container, and came over with the fluoride solution. A conventional propeller produced a vertical thrust and gave a similar effect. A flat-bladed impeller located just within the funnel solved both these difficulties. The funnel and stirrer assembly could then be lowered or raised as a unit to reduce carry-over of solids to a minimum. Considerable experimentation with flow rates through the dissolver showed that the fluoride concentration could be varied within certain limits, but best results were obtained when the device was operated slowly enough to provide a minimum retention time of about 4 hours to ensure saturation.

Pilot Model

On the basis of the successful operation of the laboratory model dissolver, a pilot model large enough for a small, community water supply was designed. Based on proportions obtained from the laboratory model, the 2-ft diameter,

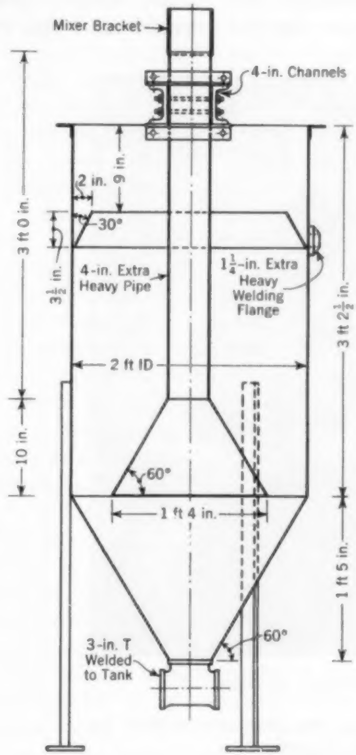


Fig. 1. Diagram of Pilot Model of Dissolver

stainless-steel pilot model was 4.5 ft high with a 60-deg cone bottom. Its liquid capacity was about 75 gal. A circular weir around the inside of the tank provided means for liquid takeoff. The central tube, corresponding to the stem of the funnel, was made of extra-heavy, stainless-steel pipe so that it could be fixed securely in position to provide a support for the mixer. Vertical adjustment of the inner cone was accomplished by a system of channels and angles bolted in the position shown in Fig. 1. A 3-in. tee was welded to the bottom of the tank to provide a cleanout for sludge. The entire tank assembly was supported by angles welded to the sides.

To prepare the dissolver for operation, the tee at the bottom was fitted with two plug valves; one for flushing water and the other for removing the sludge. The opening from the circular weir was fitted with a check valve and an ejector for removing the effluent. The 6-in. diameter, stainless-steel, flat-bladed turbine impeller was rotated at 383 rpm within the inverted funnel by means of a $\frac{1}{4}$-hp gear-driven motor. The funnel and tube assembly were bolted in position so that the bottom of the funnel was about 3 in. above the cone part of the tank.

In order to prove its practicability, the dissolver was installed in the filtration plant at Bel Air, Md., on July 6, 1956, and has been running almost continuously since then. Arrangements were made with the owners of the plant and the Maryland State Department of Health to install the dissolver in place of a sodium fluoride solution feeder.

At this plant, water is pumped at a constant rate of 500 gpm, with the raw-water pump operated manually according to the water level in the filters. En route to the settling tank, alum, soda ash, fluoride, and hypochlorite solutions are added. The flocculation zone in the settling tank provides a detention period of 5 min, and settling requires $4\frac{1}{2}$ hr. The settled

water flows by gravity to two steel, 15-ft diameter sand filters and thence to a 37,000-gal, steel clear well. A high-lift pump of 260 gpm capacity discharges to the distribution system and to the two reservoirs which ride on the system. Because fluorides were added (and still are) along with alum, some loss of fluorides occurred when the alum doses were high. Such fluoride losses continued when fluorspar replaced sodium fluoride.

Fig. 2. Fluorspar Dissolver in Use

Adjacent to the dissolver, at left, are the alum crocks used in conjunction with the dissolver.

Dissolver in Use

The dissolver was placed near the crock used for making the alum solution (Fig. 2), and was charged with 300 lb of fluorspar in an alum solution. The alum crock was charged with 50 lb of alum in 50 gal of water. This produced an alum solution of approximately 11 per cent strength. By adjusting the alum feeder supplying the dissolver, 1 mg/l fluoride could be fed to the raw water along with about 10 mg/l of alum. Inasmuch as the raw-water pump was operated intermittently, the mixer motor, alum feeder, and the solenoid valve (on the water line to the eductor) were electrically connected to the pump motor starter. This connection eliminated the possibility of feeding fluorides when the raw-water pump was idle.

The dissolver can fluoridate up to approximately 6 mil gal of water per 100 lb of 97 per cent fluorspar if the fluoride concentration is maintained at

1 mg/1 and no coagulation losses are experienced. The addition of 100 lb of fluorspar after 5–6 mil gal of water are treated will ensure a constant fluoride level, because a reserve of approximately 200 lb of fluorspar remains in the dissolver. In recharging the dissolver, 100 lb of fluorspar are ordinarily dumped into the alum solution with the stirrer running. If the fluorspar contains no flotation reagents, it sinks immediately; if flotation reagents are present, a thick foam forms on the surface of the alum solution. This foam retains a considerable amount of fluorspar, much of which does not subsequently dissolve, and is lost. The quantity of foam can be reduced by premixing small portions of fluorspar with water and pouring the mixture into the dissolver.

A clear effluent can be obtained from this dissolver at withdrawal rates up to 555 ml per minute. This is equivalent to treating 2.5 mgd at 1 mg/l F^-. The rate can be increased to 666 ml per minute (equivalent to 3 mgd at 1 mg/l F^-), but the effluent becomes cloudy. This cloudiness is caused by calcium sulfate particles formed by metathesis with the fluorspar and alum. No visible calcium fluoride particles are suspended at the lower rate.

The calcium sulfate produced (theoretically 1.7 lb of calcium sulfate is formed from 1 lb of fluorspar) must be removed periodically. Each time 100 lb of fluorspar is added to the dissolver, an equivalent volume of calcium sulfate in alum solution is removed by means of a siphon. The level of the siphon suction must be determined by trial if fluorspar removal is to be avoided. Based on the analysis of samples of sludge from different levels, it appears that the success of this process of dissolving fluorspar is based on the continuous subsidence of the fluorspar through the layer of calcium sulfate previously formed. Samples of this sludge contained 50 per cent calcium sulfate, 10 per cent alum and fluorides, and 40 per cent water.

Conclusion

At the time of writing the dissolver had been operated at Bel Air for 3 months. During this time, when the alum dosages were maintained at 10 mg/l (during periods when the source was clear), no detectable fluoride losses were encountered. When turbidity of the raw water increased, the alum dosages were correspondingly raised by operating a supplemental alum solution feeder. When the alum dose reached 100 mg/l, the fluoride loss (sedimentation tank to clear well) was about 33 per cent. To compensate for this, the dissolver feeder rate was increased, which also increased the amount of alum being fed together with the fluoride. This permitted a decrease in the supplemental alum feeder setting.

It is recognized that the dissolver described could be improved with further investigation, and that the design as shown is not the only method by which the results accomplished could be attained. The principal used for dissolving fluorspar for water fluoridation, however, is believed practical, and merits further study.

Acknowledgments

The help and encouragement of Clyde Albert, Water Superintendent at Bel Air, and Martin Flentje, Director of Research, American Water Works Service Company, Philadelphia, are gratefully acknowledged. The authors also thank Gil Montgomery of

Minerva Oil Company and Henry Siegmann of Continental Ore Corporation for providing samples of fluorspar and technical data on its use. The chemical feeder used was on loan from Proportioneers, Incorporated.

References

1. MUDD, H. T. *Industrial Minerals and Rocks.* Am. Inst. Mining Met. Engrs., New York (1949). Pp. 381–403.
2. ANON. Acid Grade Fluorspar. *Chem. & Met. Eng.,* **52**:8:130 (Aug. 1945).
3. Quarterly Report on Current Prices. *Chem. Eng. News,* **34**:26 (Jun. 1956).
4. MAIER, F. J. Fluoridation of Public Water Supplies. *Jour. AWWA,* **42**:1120 (Dec. 1950).
5. Committee Report. Fluoridation Methods and Materials—Calcium Fluoride at Brantford, Ontario. Unpublished. Am. Wtr. Wks. Assn., New York.
6. *Encyclopedia of Chemical Technology.* The Interscience Encyclopedia, Inc. Publishers, Inc. (1951).

Fluoridation Statistics in 1956

As of Oct. 1, 1956, the US Public Health Service tabulation showed that 30,470,272 persons in 1,426 communities served by 705 water supply systems were using artificially fluoridated water.

On election day, the fluoridation issue was on the ballot in many communities. The December issue of the *Journal of the American Dental Association,* in reporting unofficial returns from 43 communities which voted on the issue, noted that the measure was approved in 24 and defeated in 19. The cities on which the ADA had data included:

Approved Fluoridation

Astoria, Ore.	Morgan, Calif.
Bartonville, Ill.	Mt. Pleasant, Mich.
Cinnaminson, N.J.	Orlando, Fla.
Coos Bay, Ore.	Palmyra, N.J.
Egg Harbor, N.J.	Peoria, Ill.
Gearhart, Ore.	Peoria Twp., Ill.
Grosse Pointe Farms, Mich.	Poulsbo, Wash.
Kelso, Wash.	Richwoods Twp., Ill.
Kickapoo, Ill.	Tecumseh, Mich.
Limestone Twp., Ill.	Warrenton, Ore.
Medford, Ore.	West Peoria, Ill.
Medina Twp., Ill.	Weyauwega, Wis.

Defeated Fluoridation

Cuyahoga Falls, Ohio	Pine Bluff, Ark.
El Dorado, Ark.	Portland, Ore.
Eugene, Ore.	Redmond, Ore.
Freehold, N.J.	Riverton, N.J.
Klamath Falls, Ore.	St. Johns, Mich.
La Grand, Ore.	Salina, Kans.
Madison, N.J.	Trenton, N.J.
McMinnville, Ore.	Walla Walla, Wash.
New Ulm, Minn.	Winfield, Kans.
Wooster, Ohio	

Status of Fluoridation in the United States and Canada, 1955

Task Group Report

A report of Task Group 2620P—Fluoridation Materials and Methods, presented on May 9, 1956, at the Diamond Jubilee Conference, St. Louis, Mo., by F. J. Maier, San. Engr. Director, US Public Health Service, Bethesda, Md. Other members of the committee were R. L. Derby, H. A. Faber, A. E. Griffin, L. E. Harper, O. J. Muegge, R. W. Ockershausen, R. S. Phillips (Chairman), L. A. Smith, F. S. Taylor, H. W. Tracy, D. B. Williams, and J. C. Zufelt.

THE controlled addition of fluoride compounds to water supplies for the prevention of dental caries continued to show steady growth in North America during 1955. As of Dec. 31, 1955, there were 1,255 communities in the United States using fluoridated water supplies, serving a total population of 24,400,842 persons. These figures highlight the hundredfold growth in fluoridation in its first decade. Ten years ago, in 1945, only three communities serving 231,920 persons were receiving water with added fluorides. In Canada, too, the growth has been steady. Table 1 shows the progress which has been made.

In the United States by the end of 1955, nearly a quarter (23.9 per cent) of all communities having populations above 10,000 were receiving fluoridated water. In the thirteen cities having populations between 500,000 and 1,000,000, more than half are fluoridating the water supplies (Table 2).

In spite of the continuing growth in the number of fluoridation installations throughout the Unit d States, a number of communities have discontinued fluoridation for various reasons. The trend which was moving upward during the period 1950–1954 appears to have been reversed in 1955. To illustrate, in 1954, 20 water supply systems serving more than a million persons, discontinued the addition of fluorides, and in 1955 only sixteen fluoridated water supply systems, serving about a third as many persons, were terminated. The number of discontinued fluoridation installations should not be overemphasized because only about 6 per cent of the population served has been affected. By the end of 1955, fluoridation had been reinstituted in six water supply systems, as shown in Table 3.

Of the 1,255 communities which use fluoridated water, 1,093 are served by publicly owned water supplies. Authorization for the institution of fluoridation was given by the governing body of the community concerned, in the vast majority of cases (84.5 per cent). Less than 5 per cent of the communities have authorized fluoridation by referendum (Table 4).

Fluoride Kit Study

In the previous report of this committee (*1*) it was shown that more than 80 per cent of 520 communities

TABLE 1

*Growth of Fluoridation in the United States and Canada, 1945–55**

United States				Canada	
End of Year	Number of Water Systems Using Fluoridation	Number of Communities Served	Population Served	Number of Water Systems Using Fluoridation	Population Served
1945	3	6	231,920	1	50,000
1946	8	12	328,467	1	50,000
1947	11	16	454,748	1	50,000
1948	13	24	577,683	1	50,000
1949	29	45	985,357	1	50,000
1950	62	94	1,496,887	1	50,000
1951	171	325	4,851,420	1	50,000
1952	354	711	13,280,096	6	162,000
1953	483	944	16,708,847	8	209,250
1954	570	1,119	20,918,518	9	218,250
1955	663	1,255	24,400,842†	16	344,950

* Revised data courtesy of US Public Health Service.
† Total does not include populations served by one water system.

TABLE 2

*Distribution, by Population Segment, of United States Communities Using Fluoridation, Dec. 31, 1955**

Population Segment	Number of Communities†	Communities Using Controlled Fluoridation	
		Number	Percentage of Population Segment
1,000,000 and over	5	1	20.0
500,000–999,999	13	7	53.8
250,000–499,999	23	6	26.1
100,000–249,999	65	19	29.2
50,000– 99,999	126	37	29.4
25,000– 49,999	252	70	27.8
10,000– 24,999	778	162	20.8
5,000– 9,999	1,176	163	13.9
2,500– 4,999	1,846	200	10.8
1,000– 2,499	4,296	226	5.3
Under 1,000, and not specified	9,968	364	3.7
Total	18,548	1,255	6.8

* Data furnished by US Public Health Service.
† Source: Statistical Abstract, US Bureau of the Census, Department of Commerce, 1955.

having fluoridation installations reported that they were using permanent color standard kits for making routine fluoride determinations. For this and other reasons, the committee decided to undertake a detailed study to determine the accuracy of the most widely used kits.

This work got underway during the fall of 1955 with the cooperation of Hellige, Incorporated, and W. A. Taylor and Company, manufacturers of the comparator kits to be studied. Five water plant laboratories located in Los Angeles, Oklahoma City, Madison, Wis., and Charlotte, N.C., are cooperating with the laboratory of the US Public Health Service in this study.

Fluoridation Chemicals

It is reported that the demand for fluorides has grown to a point where additional manufacturing facilities will be required. The supply situation became "tight" for sodium silicofluoride, during the past summer, following a strike against six phosphate firms. Even after the termination of the strike, the AWWA, in a circular letter dated Oct. 31, 1955, stated that sodium silicofluoride was still in short supply while other fluoridation chemicals were "not tight" and concluded that "fluorides are available, but, perhaps, not in the form you may wish."

By the end of 1955, apparently most of the domestic fluoride producers had discontinued the manufacture of dry fluorides tinted blue, despite the fact that at least two state health departments required the use of the colored product for water fluoridation. At the end of the year, only one domestic producer and two importers were reported as sources of tinted fluorides.

Current prices on sodium fluoride and sodium silicofluoride are somewhat higher than reported by this committee for 1953 (*2*). Sodium fluoride is now

TABLE 3

*Fluoridation In tallations Instituted, Discontinued, and Reinstituted, 1945–55**

Year	Fluoridation Instituted†		Fluoridation Discontinued‡		Fluoridation Reinstituted	
	Number of Water Supply Systems	Population Served	Number of Water Supply Systems	Population Served	Number of Water Supply Systems	Population Served
1945	3	231,920				
1946	5	96,547				
1947	3	126,281				
1948	2	122,935				
1949	16	407,674				
1950	34	528,080	1	16,550		
1951	110	3,367,433	1	12,900		
1952	187	8,542,866	4	114,190		
1953	134	3,380,303	7	61,305	2	109,753
1954	105	5,256,079	20	1,062,866	2	16,458
1955	107	3,811,695§	16	333,840	2	4,469

* Data furnished by US Public Health Service.
† Total, whether or not discontinued.
‡ Total, whether or not reinstituted.
§ Does not include population served by single water supply system.

TABLE 4

*Distribution of Ownership of Supply and Agency Authorizing Fluoridation, Dec. 31, 1955**

Population Segment	Number of Communities	Ownership			Authorization				
		Public	Private	Not Specified	Governing Body Alone	Referendum	Utilities Commission	Other	Not Specified
1,000,000 and Over	1	1			1				
500,000–999,999	7	7			6	1			
250,000–499,999	6	5	1		6				
100,000–249,999	19	18	1		16			2	1
50,000– 99,999	37	31	6		33	1		2	1
25,000– 49,999	70	63	6	1	60	2	2	3	3
10,000– 24,999	162	151	11		138	12	5	5	2
5,000– 9,999	163	141	22		146	4	1	8	4
2,500– 4,999	200	177	23		168	5	6	14	7
1,000– 2,499	226	197	28	1	197	3	10	12	4
Under 1,000	154	118	36		139	7	4	3	1
Not Specified	210	184	26		151	27	28	4	
Total	1,255	1,093	160	2	1,061	62	56	53	23

* Data furnished by US Public Health Service.

TABLE 5

*Use by Fluoridating Water Systems of Various Fluorine Compounds, 1945–55**

Year	Total Water Supply Systems	Chemical Used						
		Sodium Fluoride		Sodium Silicofluoride		Fluosilicic Acid	Ammonium Fluo-Silicate	Not Specified
		Type of Feeder						
		Dry	Soln.	Dry	Soln.			
1945	3	2	1					
1946	8	4	3	1				
1947	11	5	4	2				
1948	13	5	5	2		1		
1949	29	9	10	8		1		1
1950	62	12	21	24		3		2
1951	171	29	43	77		18	1	2
1952	354	50	86	176	3	34	2	2
1953	483	60	121	246	7	40	3	5
1954	570	68	135	299	7	46	5	9
1955	663	81	156	340	11	56	5	14†

* Data furnished by US Public Health Service.

† Includes five water supply systems using sodium silicofluoride, and one using fluosilicic acid when available—all of which have used sodium fluoride on occasion; three water supply systems with controlled natural fluoride, and five with chemical not specified.

quoted at $13.50 per 100 lb in carload or truckload lots (fob factory). Sodium silicofluoride is quoted at $7.50 per 100 lb in carload or truckload lots (fob factory).

Some additional dissolving difficulties have been reported by users of sodium silicofluoride. While it is recognized that there are other contributing factors, most cases investigated thus far revealed that large-particle size of the chemical was the cause of the trouble. Sodium silicofluoride which will not pass a 100-mesh sieve does not dissolve at reasonable rates. Most users, apparently, do not specify screen sizes. Until additional information becomes available, it appears that the previous recommendations of this committee (*2*) should be used by purchasers of sodium silicofluoride. Additional information on the whole problem of dissolving fluorides in continuous dissolvers is urgently needed to evaluate properly all of the factors which enter into the problem.

TABLE 6

*Annual Cumulative Population Provided with Fluoridated Water According to Chemical Used, 1945–55**

Year	Total	Chemical Used				
		Sodium Fluoride	Sodium Silico-Fluoride	Fluosilicic Acid	Ammonium Fluosilicate	Not Specified
1945	231,920	231,920				
1946	328,467	311,747	16,720			
1947	454,748	424,028	30,720			
1948	577,683	426,963	30,720	120,000		
1949	985,357	763,193	95,884	120,000		6,280
1950	1,496,887	909,463	375,821	200,774		10,829
1951	4,851,420	1,301,689	3,232,681	302,109	4,112	10,829
1952	13,280,096	2,371,354	9,143,585	1,741,216	13,112	10,829
1953	16,708,847	2,767,394	11,929,031	1,816,708	15,612	180,102
1954	20,918,518	2,522,899	14,083,576	3,999,596	65,621	246,826
1955	24,400,842	3,249,125	15,861,469	4,936,988	65,621	287,639†

* Data furnished by US Public Health Service.
† As of end of 1955. Five water supply systems (194,593 persons) using sodium silicofluoride, and one (6,280 persons) using fluosilicic acid when available—all of which have used sodium fluoride on occasion; three water supply systems (14,056 persons) with controlled natural fluoride, and five (72,710 persons) with chemical not specified.

Since 1951 sodium silicofluoride for the fluoridation of water supplies has been the chemical of choice by most water plants. Well over 50 per cent of the installations are adding sodium silicofluoride to the water serving 65 per cent of the population supplied with fluoridated water. Notable gains have been made in the past 4 years in the use of fluosilicic acid; sodium fluoride is the choice of about a third of the water systems. Most of the smaller water systems appear to prefer the use of sodium fluoride. During 1955, there was no increase in the number of plants using ammonium fluosilicate. Tables 5, 6 and 7 illustrate the usages of these chemicals.

A complete list of fluoridation censuses is given in the references.

TABLE 7

*Chemical Used in Fluoridating Communities, by Population Segment, Dec. 31, 1955**

Population Segment	Number of Water Supply Systems	Chemical Used							
		Sodium Fluoride	Sodium Silico-Fluoride	Fluo-silicic Acid	Ammonium Fluo-silicate	Sodium Fluoride and Sodium Silico-Fluoride	Sodium Fluoride and Fluo-silicic Acid	Controlled Pumping of Natural Fluoride	Not Specified
1,000,000 and over	3		1	2					
500,000–999,999	7		6	1					
250,000–499,999	11	2	9						
100,000–249,999	25	5	17	2		1			
50,000– 99,999	35	6	25	4					
25,000– 49,999	52	12	37		1	1			1
10,000– 24,999	138	28	100	5		2			3
5,000– 9,999	115	37	65	10	1		1	1	
2,500– 4,999	120	44	61	10	3	1		1	
1,000– 2,499	110	62	27	19				1	1
Under 1,000	46	40	3	3					
Not specified	1	1							
Totals	663	237	351	56	5	5	1	3	5

* Data furnished by US Public Health Service.

Acknowledgment

The committee is greatly indebted to the US Public Health Service for providing the statistical data appearing in the foregoing tables and figures.

References

1. COMMITTEE REPORT. Census of Fluoridation in the United States and Canada, 1954. *Jour. AWWA*, **47**:1210 (Dec. 1955).
2. COMMITTEE REPORT. Census of Fluoridation in the United States and Canada, 1953. *Jour. AWWA*, **46**:920 (Sep. 1954).
3. COMMITTEE REPORT. Census of Fluoridation in the United States and Canada, 1952. *Jour. AWWA*, **45**:893 (Aug. 1953).
4. TASK GROUP REPORT. Natural and Applied Fluoridation Census. *Jour. AWWA*, **44**:553 (Jun. 1952).

EDITOR'S NOTE: *Because of its size, it is impractical to continue publication of the census of communities starting fluoridation each year. Census totals alone will be provided. The progress report of the task group will be published annually.*

Automatic Controls in Pumping Stations at Giddings, Tex.

Richard A. Toler

A contribution to the Journal by Richard A. Toler, City Mgr., Giddings, Tex.

THE city of Giddings has two pumping stations, each equipped with two 500-gpm high-lift pumps. Each station has two wells which pump into ground storage tanks. Station No. 1 is fully automatic and wells No. 3 and 4, which are 1,378 ft deep, supply it with 90 gpm and 270 gpm, respectively. Both wells pump into a 50,000-gal ground storage tank. The high-lift pumps move water from the ground storage tank into the mains where it backs up into a 100,000-gal elevated storage tank.

The manner of operation of both stations is the same and each can operate independently or in combination with the other. At station No. 2 well No. 5 pumps 380 gpm into a 300,000-gal ground storage tank, and No. 6 pumps 540 gpm into the same ground storage tank. Well No. 5 is 1,210 ft deep and No. 6 1,378 ft deep. The high-lift pumps are numbered 3 and 4.

Description of Plant

The pump station, shown in Fig. 1, is entirely fireproof, constructed of brick, with concrete roof, concrete floors with asphalt tile covering, steel windows and steel door. The entrance door is equipped with an exterior light with a weatherproof exterior switch, so that the light can be used when unlocking the door. Five colored signal lights which are mounted on the exterior of the building for indicating plant operations at night enable the yardman to tell at a glance which pump is operating and the level of the ground storage tank. To one side of the pump station is a separate power station with fenced-in transformers, high-voltage switches, capacitors, and oil switches. This electric substation supplies only the pumping station. Power enters at 12,500 v and is reduced to 120 and 240 v for lighting and pump operations. At the other side of the station, enclosed by steel fence, is well No. 5, equipped with a 380-gpm pump. Both the electric substation and well No. 5 are equipped with watertight floodlights. The pipe extending into the air (Fig. 1) from well No. 5 is a vent pipe, which relieves air locks and makes it unnecessary to use air release valves on the discharge line. This well is equipped with a 40-hp motor, and the pump bowls are set 340 ft down, in the well. Directly behind the pump station is the 300,000-gal concrete, ground storage tank. Well No. 6 is equipped with a 540 gpm pump, driven by a 60-hp motor, with pump bowls 340 ft below ground level. Well No. 6 pumps into the 300,000-gal ground storage tank

only, but well No. 5 is equipped to pump into either the 300,000-gal ground storage tank of station No. 2 or into the 50,000-gal ground storage tank of station No. 1. A storm sewer was installed to handle the overflow of the ground storage tank. Each well has a valve through which it can pump into the storm sewer opening in each well enclosure. Pump drippings from high-lift pumps and drainage from roof drains are also piped into the storm sewer. In addition to this, the entire property is curbed, with an opening at each corner into the storm sewer, to keep the premises dry. Sidewalks are laid to avoid tracking mud into the plant in wet seasons.

Figure 2 shows one of the 500-gpm high-lift pumps in use in Station No. 2. This pump is equipped with a 30-hp motor and a 1-in. priming line which runs from the top of a nonslam check valve to the top of the pump case. The suction line is equipped with a 6-in. valve because the water level is above the pump suction level when the ground storage tank is entirely filled. This valve is shown (Fig. 2) between the pump and the building wall. The discharge line is equipped with a 3-in. valve and increases to 6-in. size immediately after passing the valve. A fan mounted on the wall aids in lengthening the life of the motor during extremely hot weather. The building is heated by an automatic heater shown in Fig. 2 on the wall above the pump. In the same illustration, the large case on the left houses a 60-hp automatic, reduced-voltage, compensating starter that controls the motor on well No. 6. The box above the fan houses a combination switch

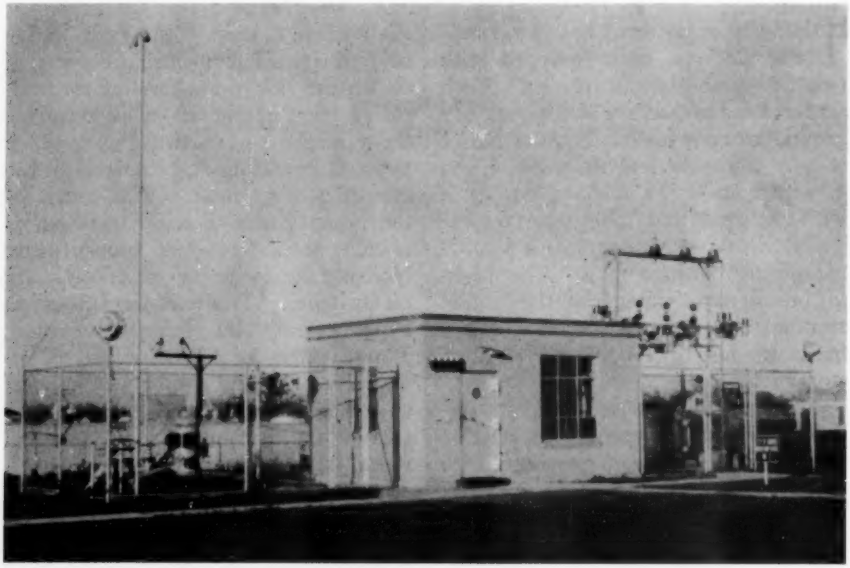


Fig. 1. Pumping Station No. 2, Giddings, Tex.

and magnetic starter that controls high-lift pump No. 3. The small switch box on the wall (displaying the number "8") controls the heater only. The largest switch box is the main switch of well No. 6, and duct work shown at the top houses the main bus bars, which supply power to the entire plant.

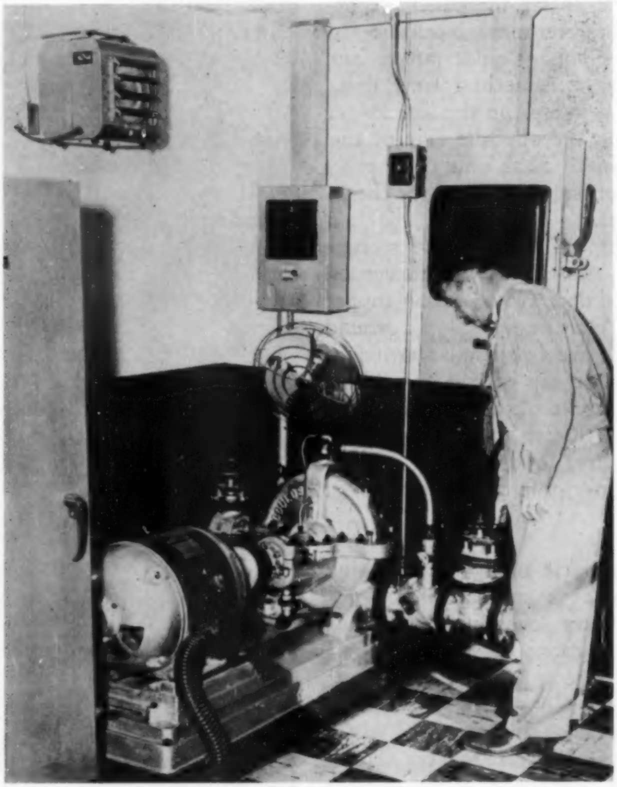


Fig. 2. One of the High-Lift Pumps at Station No. 2

Control Panel

On the pilot control panel (Fig. 3), the gage at bottom left registers distribution pressure. At right is a vacuum gage connected to the suction line of the pumps. The row of colored pilot lights above the gages indicates (left to right) the level of the elevated storage tank (red), the level of the ground storage tank (amber) and whether it is necessary for the well to pump in order to fill the ground storage tank (green). Above the pilot lamps are the switches which enable the operator to select manual, off or automatic position for the high-lift pumps No. 3 and 4 and for well No. 5. The test block above the selector switches allows proper testing of the power meter,

which is above the test block. At the top of the panel are three time delay relays for high-lift pumps No. 3 and No. 4 and for well No. 5. The opposite side of the panel houses identical equipment for well No. 6, and space for additional pumps that might be added later. Inside the panel are by-pass switches, terminal blocks, resistors for low-voltage pilot lamps, and other wiring. A second time delay relay to hold pumps on the line longer is located on the opposite side of this control cabinet. Each time delay relay has two pilot lamps attached for checking purposes.

At the top of the elevated storage tank is a two-circuit, weatherproof, rod-operated float switch with a copper float ball. On the 50,000-gal ground storage tank are two similar switches, and, located on top of the 300,000-gal ground storage tank are two more of the same. All five of these switches have protective housings to prevent sleet from interfering with their action.

Operation

A typical cycle of operation, using station No. 2 as an example, begins when the water level in the elevated storage tank drops 18 in., causing a float to activate a switch. Current is then carried by underground cable to the pilot panel of station No. 2 where it closes a small relay. This illuminates a red pilot lamp under selector switch No. 3, indicating that the elevated tank lacks water. At the same time current is sent to the time delay relay on pilot panel which begins to wind. Pilot lamps at the left side of the relay then light, indicating to a troubleshooter that current has successfully reached the relay. After 1 minute, the time delay relay on pump No. 3 closes, energizing a magnetic relay which in turn starts No. 3 high-lift pump, drawing water from the ground storage tank and, at the same time, causes a pilot lamp on the exterior of the station to light, giving the signal

Fig. 3. View of the Pilot Control Panel

that the pump is in operation. When the time delay relay closes, the red pilot lamp at the left of the relay goes out and a green pilot lamp at the right of the relay lights, indicating to a

troubleshooter that current has passed the relay. After 1.5 min, the same operation occurs on high-lift pump No. 4, and it also starts pumping. This staggered "on operation" causes less surge on the water lines.

As the high-lift pumps take water from the ground storage tank, the level of the tank lowers. When 40,000 gal of water has been drawn from this storage tank, the green light at the bottom of the panel is illuminated. This is actuated by a float switch on the ground storage tank. At the same time current is sent to the time delay relay of well No. 5, and after 3.5 min this relay closes, extinguishing the red light, lighting a green light, and energizing a magnetic starter that starts high-lift pump No. 4. At the same time a pilot lamp on the exterior of the building lights, indicating that pump No. 4 is in operation. When the elevated tank has been filled, the red pilot lamp is extinguished by the float switch breaking contact, and high-lift pump No. 3 stops immediately. However, high-lift pump No. 4 runs for an additional minute. This staggered "off operation" causes less surge and shock to the lines. The well or wells continue to operate until the ground storage tank has been completely filled. The time delay relays prevent backspin on the wells in the event of a short power failure, and also cause the electric motors to begin operation gradually, instead of draining the transformer output simultaneously. If a high-lift pump fails to come on at its proper time, the operator can recognize it at once from the pilot lamps. The pressure will also begin to drop and, since the pressure gage is equipped with a stationary hand set to the lowest desired pressure, the operator knows there is no danger so long as the moving hand remains above that point.

The amber light, directly under selector switch No. 4, burns as long as there is a minimum of 160,000 gal of water in the 300,000-gal ground storage tank. When a well fails and this level is reached, the safety float switch breaks contact and the amber light goes out on the panel. At the same time, a small, master relay is deenergized and the high-lift pumps stop operation. The pressure then begins to fall, calling attention to some disturbance. At the same time, 160,000 gal of water remain available for pumping while corrections are being made. If a time delay relay fails, the operator merely puts into operation a bypass switch allowing pumps to operate manually or automatically while the relay is being repaired.

Savings

During the years 1941–1952 the city estimated a savings of $42,000 by using automatic station No. 1 (built in 1941). In 1952, station No. 2 was built, and only one operator is now used to operate both stations. This man also does general maintenance of the premises. No operator is on hand at night, and the night watchman checks the gages during his rounds. The city operates four wells and four high-lift pumps on its water system, and seven pumps on its sewage system. Al' are fully automatic and save the city much expense each year.

Liquid Alum at Milwaukee

James E. Kerslake

A paper presented on Sep. 26, 1956, at the Wisconsin Section Meeting, LaCrosse, Wis., by James E. Kerslake, Supt. of Filtration, Water Purification Plant, Milwaukee, Wis.

LIQUID alum is dry alum in solution. When purchasing bids are taken on both dry and liquid alum, price comparisons are made on the basis of dry alum containing 17 per cent aluminum oxide. Liquid alum has a specific gravity of approximately 1.33 at 60°F and contains 49–50 per cent dry alum. A typical analysis made at the Milwaukee treatment plant is shown in Table 1.

The principal advantages of using liquid alum are that it is both cheap and easy to handle. Savings of about 10 per cent are made at the manufacturer's plant by avoiding chemical processes involved in the making of dry alum. More savings are added in handling the liquid at the treatment plant where it is simply fed from the tank in which it was transported directly into the storage tank. The truck driver connects the delivery line, and the entire operation takes no more than 20 min. In Milwaukee, the handling rate of dry alum delivered in carloads is $2.08 a ton.

The advantages of using the liquid can, however, be easily lost if the manufacturer is far from the treatment plant. The liquid is approximately 50 per cent water, and the costs of hauling water are about the same as those of hauling dry alum. The plant in Appleton, Wis., for example, purchases liquid alum made in Menasha, Wis., less than 20 miles away, at a cost of $1.78 per hundredweight (dry basis). Milwaukee, using ten times as much liquid alum per year, must buy its supply in Joliet, Ill.—135 miles away. Milwaukee must thus pay $1.99 per hundredweight (dry basis).

Shipping Alum

Liquid alum is shipped in rubber-lined steel tank cars of 10,000-gal capacity, or rubber-lined steel tank trucks with 3,000–4,000-gal capacity. In colder climates where below freezing weather is experienced, delivery should be made in tank trucks approximately 8 hr after the truck has left the manufacturing plant: liquid is shipped at a 100°–120°F temperature. If tank cars are used and a longer delivery time is required, provision should be made for insulating the cars. It is claimed that the liquid alum can be handled when the temperature of the liquid is as low as 10°F, but it is safer not to allow the temperature to fall below 25°F. Another factor to keep in mind is that, when the material is delivered to the plant in tank trucks, the road from the highway into the plant should be capable of supporting heavy loads without damage.

Operations

In Milwaukee, provision was made for using liquid alum after dry alum feeding equipment had been in service for 16 years. The equipment and a

supply of dry alum have not been discarded, but simply are kept in reserve. When switching installations, three stainless steel tanks which had been a part of the dry feeding equipment were kept in service.

The equipment installed included: two lead-lined steel storage tanks ($9 \times 10 \times 13$ ft), each with an 8,700-gal capacity; two motor-driven acid-resistant pumps; three orifice boxes; and the necessary electrical control devices and piping. Plastic piping and valves were used except for a 3-in. stainless steel pipe which conveys the liquid alum from the delivery truck to the storage tanks. Except for the erection of storage tanks, the electrical work, painting, and installations were done by the plant maintenance force. The pumps deliver the liquid alum from the storage tank to the stainless steel feed tanks. The liquid then flows through orifice boxes and lead-lined steel troughs to the point of application. The pump feeding rate is greater than the orifice box intake capacity so that the overflow returns to the storage tanks, and sets up a continuous circulation. From the cost of installation shown in Table 2 it will be noted that the direct cost was $15,554.78. As the Milwaukee plant purchased 2,100 tons of dry alum a year, and the saving per ton of the liquid is $3.60, the annual saving is $7,560. The installation will have paid itself off in 2 years. After adding indirect costs of feeding the dry alum ($3.60 + $2.08), there is a total saving of $5.68 a ton, or $11,929 a year. The total cost of installation which includes labor comes to $23,496.48. Thus, the total cost can be paid off within 2 years.

TABLE 1

*Typical Analysis of Liquid Alum**

Contents	Percentage of Total
R_2O_3†	8.78
F_2O_3	0.27
Al_2O_3	8.51
H_2SO_4	
Equivalent to Al_2O_3	24.57
H_2SO_4	
Equivalent to Fe_2O_3	0.50
H_2SO_4	
Total required	25.07
Free Al_2O_3‡	0.60

* Shipment received Jul. 2, 1956. Temperature was 60° F, sp gr 1.333, and hydrogen ion concentration 1.73.
† R_2—combined oxides precipitated with ammonia.
‡ Free Al_2O_3 is the amount of aluminum oxide in excess of that required to combine with the sulfuric acid to form aluminum sulfate.

TABLE 2

Cost of Installing Tanks at Milwaukee

Item	Price—$
Steel plate	2,506.00
Erection	2,839.45
Plans	824.28
Two motor-driven pumps	734.28
Three orifice boxes	659.00
Electrical accessories	330.84
Plastic piping and valves	811.45
Lead lining*	2,993.00
Painting	114.00
Electrical equipment installation	567.96
Bolts, nuts, special tool, steel piping elbows	914.37
Spare parts	950.00
Additional charges†	1,309.65
Total	15,554.78
Plant labor‡	7,941.70

* Including freight.
† Moving steel plates into basement of building.
‡ 3,054½ hr at $2.60 per hour; includes all costs of installing pipes and tuning up.

The application of liquid alum by the orifice box can be made almost as accurate as that of dry alum by the loss-in-weight dry feeder. At Milwaukee, a 80–120-ppm dose is used. With the orifice boxes, the dose can be kept within plus or minus 5 ppm.

To maintain uniformity and prevent a change in level, a lead pedestal has been installed in the orifice box. The orifices are cleaned once each shift. Gages installed on the storage tanks measure the drop in level. Where a tank is not of the overflowing type, a gage can be installed and the liquid fed at a predetermined rate. It has not been found necessary to dilute the material received since operations began in April 1955.

Liquid alum can be applied by means of an orifice box, a rotameter, a proportioning pump, or a volumetric solution feeder. Plastic, rubber-lined, or stainless steel pipe are required for handling the liquid alum solution. Pumps capable of handling acid should be used. Generally, lead-lined steel or lead-lined concrete tanks are used for storage, capable of storing at least a 30-day supply when there is no dry feed reserve. Two tanks and two pumps are provided although only one set is used at the time. With the development of air-conditioning and dust-removal equipment, there has been a tendency to save building costs by utilizing underground storage tanks, even for dry feed equipment.

In conclusion, then, it can be seen that the advantage in using liquid alum is primarily one of costs. Before a decision is reached, a careful and accurate cost analysis should be made of installation and operating costs. This applies to new plants as well as to those already in operation.

Fire Underwriters Grading Schedule Available

The 1956 edition of the *Standard Schedule for Grading Cities and Towns of the United States With Reference to Their Fire Defenses and Physical Conditions* has recently been published by the National Board of Fire Underwriters. The first edition of this schedule was published in 1915, with subsequent editions in 1917, 1922, 1930, and 1942.

Some modifications have been made in the new edition to recognize present good practice and modern developments, but these will not materially affect previous gradings of municipalities that have progressed with the times. Changes in wording and arrangement have also been made to clarify the meaning of certain sections and to make the schedule more convenient to use.

Single copies may be obtained from the National Board of Fire Underwriters, 85 John St., New York 38, N.Y.

Measurement of Small Quantities of Hydrocarbon in Water

Carl-Gustav Lindgren

A contribution to the Journal by Carl-Gustav Lindgren, Chem. Engr. at the National Institute of Public Health, Stockholm, Sweden.

THE increasing use of petroleum products for public transport, domestic heating, and other purposes, has produced a water pollution problem. Both in distribution and storage, the possibilities arise of spillage and leakage that can lead to the pollution of ground water. The problem has been dealt with by several authorities (*1–9*). Even at very low concentration, petroleum products impart an odor and taste to water. According to Gibbon (*10*) the threshold for olfactory perception of gasoline in water is 0.2 mg/l and for fuel oil 0.7 mg/l. Melpolder et al. (*11*) state that in the case of one of their laboratory workers, the perception threshold for gasoline was 0.005 mg/l water, and the same figure is given (*12, 13*) for the neutral compounds of the extract removed by activated carbon filters from the water supply of a number of American cities. Research by the National Institute of Public Health has established the threshold for fuel oil (Grade 1) and gasoline at 0.05–0.1 mg/l water.

For the prompt tracing of petroleum product pollution, there is a need for an analytical method with a higher sensitivity than that used in the above assessments. The methods employed previously have been capable of detecting and measuring petroleum pollution only in excess of about 2 mg/l water. These methods are based on a weighing system and have been used for checking waste water from oil refineries and for checking steam boiler makeup water (*14–23*). With these methods, one estimates not the hydrocarbon content of the water, but the substances extracted from the water with the aid of solvents such as ether, chloroform, carbon tetrachloride or benzene. The American Society for Testing Materials (*15*), thus, does not give the *oil content* but the *oily matter content,* a term that implies the substances extractable with chloroform or benzene, and which comprise the residual after the solvent is evaporated. In recent years, much work has been devoted to the development of more sensitive methods. Several researchers (*24–28*) have suggested methods based on the measurement of fluorescence. These methods are likewise not specific, the intensity of fluorescence varying in accordance with the origin of the petroleum product involved and the processes to which it has been subjected. Melpolder and colleagues (*11*) have proposed a mass-spectrographic method, the sensitivity of which is reported to be 10 mg per cubic meter. This method is limited in its application to hydrocarbons with a boiling point lower than 170°C. The method showing the greatest possibilities has been offered by Simard and colleagues

(*29*) and is based on mechanical shaking with carbon tetrachloride and the measurement of the infrared absorption of methylene and methyl groups at 3.38, 3.42, and 3.51 μ. The sensitivity of the method is reported to be 0.1 mg/l. Since this method estimates the CH_2 and CH_3 groups of the compounds separated, it is not specific for hydrocarbons.

The present paper describes a specific technique which uses the above-mentioned infrared method, but which separates hydrocarbons and non-hydrocarbons chromatographically.

TABLE 1

Extractions of Petroleum Products by Use of 20-ml Portions of Carbon Tetrachloride*

Extraction	Lube Oil mg/l		Fuel Oil (Grade 1) mg/l		Gasoline mg/l	
1	64.2	63.0	49.5	50.4	12.7	11.2
2	0.8	0.6	0.9	1.0	0.3	0.6
3	0.1	0.1	0.1	0.1	0.1	0.2
4	0.1	0.1	0.1	0.1	0.1	0.1

* Two samples of each product were used.

Chromatographic Separation

According to Feigl (*30*) most of the polar adsorbent materials that are used in chromatography adsorb saturated hydrocarbons to a lesser extent than other substances. Rosen and colleagues (*31*) have used adsorption chromatography on extracts obtained from waste water of oil refinery origin for the purpose of distinguishing between aliphatic and aromatic hydrocarbons. Wedgwood and Cooper (*32*) also separated aromatic hydrocarbons in waste water by means of chromatography. More recently, Ludzack and Whitfield (*33*) investigated oil pollution in water by means of aluminum oxide chromatography and infrared analytical techniques. The present study also involved the use of aluminum oxide and the solvent carbon tetrachloride.

Organic substances containing the carbon-hydrogen linkage (C—H) absorb within the waveband 3–4 μ (*34, 35*). Unsaturated hydrocarbons exhibit the greatest absorption in the waveband 3.23–3.35 μ, while saturated hydrocarbons absorb in the wavelength region between 3.38 and 3.52 μ. The CH_3 group shows the strongest absorption in the bands 3.38, 3.42 and 3.49 μ with the strength of the absorption decreasing in that order. The CH_2 group absorbs at 3.41 and 3.51 μ. The absorption of CH is somewhat uncertain but Fox and Martin (*35*) suggest that it lies at 3.46 μ. The absorption characteristics of this group are thus considerably weaker than that of the other groups. From the preceding, it follows that absorption in the 3.38 μ band is the result of the CH_3 group, and the absorptions at 3.42 and 3.51 μ are produced by CH_3 and CH_2 together.

TABLE 2

Extractions From Water Contaminated by Fuel Oil for Long Period

Extraction	Fuel Oil (Grade 1) mg/l
1	20.2
2	5.2
3	2.6
4	1.6
5	1.1
6	0.8
7	0.6
8	0.5

Technique

Two machines were used for extraction; one provided an oscillating

action with a speed of 200 cycles per minute and a stroke of 5 cm, and the other employed a rotary action at 22 rpm. Extraction was carried out in flasks of 0.5- and 1-liter capacity, fitted with ground-glass stoppers. For chromatography, tubes 140 mm long and 12 mm in diameter were used.

The absorption measurements of infrared radiation were performed with a Perkin-Elmer, type 112, double-pass spectrometer with sodium chloride prisms. The cells, 38 mm long and with a capacity of 20 ml, were specially made. They were of glass, the ends being formed of microscope cover slips cemented with Clifflim (a commercial adhesive). In view of the fact that the measurements were limited to between 3 and 4 μ, glass could be used, making the cells cheap and strong.

It was necessary that the carbon tetrachloride possess low absorption characteristics at the wavelengths to be measured. An absorption corresponding to 5 mg of hydrocarbon per liter was set as the upper limit for the carbon tetrachloride. Every bottle of reagent was subject to analysis, and about one in three was rejected. For chromatography, acid and basic aluminum oxide was used.

The base curve was prepared from trimethylpentane and hexadecane obtained from Eastman Kodak, and benzene obtained from Riedel de Haen. Analyses were performed on petroleum products available on the Swedish market.

Separation was carried out in flasks fitted with glass stoppers because carbon tetrachloride dissolved the organic compounds of cork, rubber, and plastic stoppers. The greatest care was necessary throughout the analysis to preclude contamination from any organic foreign matter. All ground-glass surfaces were treated with carbon tetrachloride, and sintered-glass filters were used for all filtration. Further, no water was transferred from one flask to another, because petroleum products form emulsions that tend to adhere easily to the inside walls. Shaking was carried out in two stages with the addition of 15 ml carbon tetrachloride at each stage. Between the stages, the carbon tetrachloride was drawn off, together with some water, and transferred to a separatory funnel where the extract was separated. Precautions were taken to minimize the carry over of water with the carbon tetrachloride because water can effect the chromatographic separation and the measurements by infrared absorption. Water with a low humus content was agitated in the more violent shaker, and water with a high humus content—with its higher risk of emulsification—was agitated in two stages of 120 min each under milder conditions. After separation, the carbon tetrachloride was chromatographed through a column consisting of 50 per cent acid and 50 per cent basic aluminum oxide.

TABLE 3

Slight Adsorption of Hydrocarbons by Acid and Basic Aluminum Oxide

Fraction	Oil Concentration in Eluate Fractions *mg/ml*	Total Oil Recovered in Eluate *mg*
1	0.003	0.03
2	0.159	1.62
3	0.200	3.62
4	0.208	5.70
5	0.178	7.48
6	0.045	7.93
7	0.011	8.04
8	0.003	8.07

The chromatographic column was prepared according to the "wet" method, in which the aluminum oxide was mixed with carbon tetrachloride and poured into the tube to a height of 12 cm (6 cm of the basic and 6 cm of the acid aluminum oxide). When the adsorbent settled, it was covered with a thin layer of glass wool to prevent any disturbance in the top layer during the subsequent addition of solvent. When the level of the pre-wet solvent had drained to the top surface of the adsorbent, the extract was added. The first 10 ml of the eluate (the column contained 11 ml solvent) was used as the first washing fluid, and was added when the extract had drained to the top of the adsorbent. When the first 10 ml of the washing fluid had drained to the top of the bed, 10 ml of fresh solvent was added. The collection of eluate was not interrupted until the solvent had stopped draining—which occurred soon after the last washing fluid had drained to the top of the adsorbent bed. The volume of the eluate ranged between 34 and 37 ml, which makes a dilution of the first extract by about 10 ml. The absorption curve of the eluate was then recorded twice in the wavelengths spanning 2.8 to 4 μ.

Calculation

The calculation of absorption for the three wavelengths 3.38, 3.42, and 3.51 μ was carried out by the base line method given by Heigl and colleagues (*36*). In the equation $A = \log I_B/I$, used to calculate the base line absorbance, A is base line absorbance, I is distance on the recorded spectrum from the zero line to the selected absorption peak, and I_B is distance from the zero line to a straight line (the base line connecting the two spectral points located at 3.01 and 3.87 μ). I_B is measured at the same wavelength as I. The method yields an absorption value which is corrected for carbon tetrachloride's own absorption.

TABLE 4

Chromatographic Recovery of Various Petroleum Products

Product*	Quantity Added Before Chromatography—*mg/l*	Quantity Found After Chromatography—*mg/l*	Recovery %
Gasoline A	1.34	1.25	93
Gasoline A	1.34	1.21	90
Gasoline B	1.11	0.93	84
Gasoline B	1.09	0.92	84
Motor fuel oil A	1.26	1.17	93
Motor fuel oil A	1.26	1.13	90
Motor fuel oil B	1.14	1.02	89
Motor fuel oil B	1.22	1.04	85
Fuel oil A (Grade 1)	1.20	1.08	90
Fuel oil A (Grade 1)	1.19	1.05	88
Heavy duty motor lube oil	1.27	0.92	72
Fuel oil B (Grade 4)	1.08	0.72	67
Fuel oil B (Grade 4)	1.08	0.68	64

* In all cases but one, two samples of each product were used.

Since preparation of a standard solution is difficult, the efficiency of the extraction was determined by repeated shakings of the same water solution. Certain amounts of various petroleum products were separately suspended in 1-liter volumes of water, and extraction was performed with 20-ml portions of carbon tetrachloride. Between extractions, all traces of carbon tetrachloride were carefully separated from the water. The results are given in Table 1 which shows that the extraction efficiency was very good, even at the first stage. The hydrocarbon content in the succeeding extraction stages was probably the result of incomplete separation of the carbon tetrachloride. Extraction by means of two portions of 15 ml results in 95 per cent removal efficiency under most circumstances.

The extraction of water which had been contaminated for a long period with fuel oil (Grade 1) gave the interesting results shown in Table 2. The appreciably lower extraction efficiency was probably caused in part by the oxidation of some of the hydrocarbons (*37, 38*) present in the petroleum product, thus leading to an increased content of hydrophilic substances.

That oxidation had taken place was proved both by the reduced values given by chromatography and also by the appearance of C=O bands in the infrared spectra. The oxidized substances were separated by chromatography. It is not known to what extent these substances impart a taste and odor to the water, but the results obtained in certain investigations carried out by the institute suggest that their effect may be similar to that of pure hydrocarbons.

Hydrocarbons were adsorbed only to a slight extent by acid and basic aluminum oxide as is seen in Table 3. Forty milliliters of a solution of 0.217 mg fuel oil (Grade 1) per milliliter CCl_4 was poured through a column prepared as already described. When this solution had drained down to the top of the bed, the column was washed with 40 ml of fresh carbon tetrachloride. The concentration of the oil in the eluate was measured in successive 10-ml fractions.

Table 4 shows the recovery possible by the prescribed chromatographic procedure in the case of a number of different petroleum products. A recovery of about 90 per cent was obtained with volatile petroleum products, while those containing hydrocarbons of high boiling points (lubricating and heavier fuel oils) gave a lower figure, because of the greater ease with which the aluminum oxide adsorbed these products. More thorough washing with carbon tetrachloride increases recovery, but the corresponding dilution of the test liquid results in a corresponding loss of accuracy.

A further study was conducted on the effect which certain added organic substances exert on the method described in this paper. The data are presented in Table 5.

Except for a shale oil sample, the mean value of the angular coefficient for the approximately straight line representing the relation between concentration, in terms of milligrams of hydrocarbon per milliliter of carbon tetrachloride, and the sum of the absorbances ($\Sigma \log I_B/I$), was found to be 15.45 ± 2.25 with 95 per cent certainty. The variations between different products were mainly the result of the varying content of aromatic hydrocarbons. The strongest absorption for benzene occurs at about $3.27\ \mu$, but was not measured. This absorption is considerably weaker than the absorp-

tion for the aliphatic hydrocarbons, and, thus, a measurement becomes practical only with relatively high aromatic hydrocarbon concentrations. The mean value for the angular coefficients was used as the basis for drawing the standard curve shown in Fig. 1. To make it possible to use these values in other laboratories the curve for the standard compound suggested by Simard and colleagues (*29*) (37.5 per cent trimethylpentane, 37.5 per cent

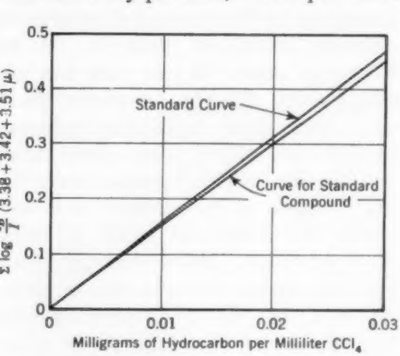


Fig. 1. Standard Calibration Curve

The mean value for the angular coefficients provided the basis for the standard curve.

hexadecane and 25 per cent benzene) has also been shown.

The curves for the various petroleum products vary but slightly from Beer's law and can, as shown in Fig. 1, be replaced with straight lines up to 0.05 mg per milliliter of carbon tetrachloride.

Accuracy

Carbon tetrachloride's own absorption in relation to the base line was established after eight tests, 99.9 per cent of the blanks being within the value ±0.00077 mg per milliliter of CCl_4, which corresponds to 0.023 mg hydrocarbon per 30 ml carbon tetrachloride. The apparatus blank approximates 0.05 mg at low hydrocarbon concentrations. Errors arising from incomplete separation of the hydrocarbon and nonhydrocarbon compounds by chromatography are difficult to detect. The composition of the extracts collected from a number of water samples was examined. The data in terms of milligrams of hydrocarbon per liter of water are presented

TABLE 5

Influence of Added Organic Substances on Analytic Techniques Described

Substance Added to Water —*mg/l*		Apparent Concentration—*mg/l* Infrared Absorption Method	Apparent Concentration—*mg/l* Authors' Method
Ethyl alcohol	1,000	0.3	<0.1
Acetone	100	0.2	<0.1
Acetic acid	100	0.2	<0.1
Formic acid	10	3.5	<0.1
Oleic acid	10	8.4	0.2
Vanilin	100	0.4	<0.1
Margarine	10	9.8	<0.1
Gravel (washed) —100 g		0.1	<0.1
Soil (washed) —100 g		0.2	<0.1

in Table 6. In Sample 10 of the table, the infrared absorption exceeded a value of 0.1 mg hydrocarbon per liter of water. This water had fairly large but light floc particles and a demand of potassium-permanganate of 20 mg/l (boiling for 20 min in an acid solution of 15 ml .01*N* $KMnO_4$ to 100 ml of the sample).

When dealing with well water one must reckon with a certain extractable content that cannot be separated from petroleum hydrocarbons during chromatography. If the zero absorption

for a water is not known, the limit of accuracy of the method is fixed at 0.2 mg/l (± 0.1 mg/l).

It is often desirable to perform a qualitative analysis for petroleum pollution. During the last year, attempts have been made at the institute to identify organic substances by absorption in activated charcoal and by chromatographic separation of the ether extract. The infrared spectra of the various fractions offer great possibilities for the identification of the organic pollution of water.

TABLE 6

Illustration of Possible Error Arising From Incomplete Chromatographic Separation of Hydrocarbons and Nonhydrocarbons

Water Sample	Milligrams of Hydrocarbon per liter of water	
	Before Chromatography	After Chromatography
1	0.09	0.06
2	0.11	0.06
3	0.06	0.01
4	0.08	0.02
5	0.07	0.02
6	0.07	0.02
7	0.04	0.02
8	0.04	0.00
9	0.06	0.03
10	0.17	0.16
11	0.02	0.06

Conclusion

The estimation of gasoline and oil in water to a level of 0.1 mg/l, with an accuracy of 0.05 mg/l, is possible by means of extraction with carbon tetrachloride, chromatography, and absorption measurements at the wavelengths 3.38, 3.42 and 3.51 μ—so long as the water's zero absorption is known. In other cases, estimation can be made to 0.2 mg/l with an accuracy of 0.1 mg/l by use of chromatography with aluminum oxide. A good separation of hydrocarbons and other contaminating substances can be accomplished.

Acknowledgment

This investigation was carried out at the water laboratory of the National Institute of Public Health in Stockholm. It was started by L.–E. Thuresson, and completed by the author.

The author wishes to thank the head of the institute, E. Abramson, and the head of the water laboratory, E. Ljungholm, for valuable advice, and Mrs. Siv Gustafsson and A. Ostberg for assistance in the experiments.

References

1. FRICKE, K. & KRAUSE-WICHMANN. Heavy Ground Water Pollution of the River Wesel by Benzine. *Gesundh. Ing.* (Ger.), **74**:394 (1953).
2. MÜLLER, JOSEF. Significant Determination of the Pollution of Ground Water by Benzine. *Gas und Wasserfach* (Ger.), **93**:205 (1952).
3. STENBERG, A. Pollution of Ground Water by Stored Oil. *Vattenhygien* (Swed.), **8**:64 (1952).
4. THOMAS, P. Pollution of Water Supplies by Benzine or Similar Products. *Gesundh. Ing.* (Ger.), **55**:8 (1932).
5. THURESSON, L.-E. Pollution of Water by Petroleum Products. *Vår Föda* (Swed.), **6**:1 (1954).
6. TROEDSSON, T. Ground Water Pollution by Benzine and Its Hydrogeological Aspects. *Vattenhygien* (Swed.), **5**:25 (1949).
7. ULLERSTAM, A. On the Risks of Ground Water Pollution by Oils and Similar Fluids. *Vattenhygien* (Swed.), **6**:33 (1950).
8. CUNNINGHAM, MORRISON B., ET AL. Oil Pipeline Failures and the Water Industry. *Jour. AWWA*, **46**:1033 (Oct. 1954).
9. Threat to Water Supply From Oil Pipeline Break Averted in Batavia. *N.Y. Taste and Odor Control J.*, **11**:1 (1952).

10. GIBBONS, M. MORTIMER. Water Pollution by Petroleum Oils. *Jour. AWWA*, **32**:465 (Mar. 1940).

11. MELPOLDER, F. W., ET AL. Mass Spectrometer Determination of Volatile Contaminants in Water. *Anal. Chem.*, **25**:1453 (1953).

12. MIDDLETON, F. M., ET AL. Fundamental Studies of Taste and Odor in Water Supplies. *Jour. AWWA*, **44**:538 (June 1952).

13. RUCHHOFT, C. C., ET AL. Taste- and Odor-Producing Components in Refinery Gravity Oil Separator Effluents. *Ind. Eng. Chem.*, **46**:284 (1954).

14. *Standard Methods for the Examination of Water, Sewage and Industrial Wastes.* APHA, AWWA, & FSIWA, New York (10th ed., 1955).

15. Proposed Tentative Method of Test for Oily Matter in Industrial Waste Water. *Am. Soc. Testing Materials*, Philadelphia, Pa. Preprint No. 49 (1954).

16. HEADINGTON, C. E., ET AL. Methods for Determining Hydrocarbons and Phenols in Water. *Anal. Chem.*, **25**:1681 (1953).

17. KIRSCHMAN, H. D. & POMEROY, RICHARD. Determination of Oil in Oil-Field Waste Waters. *Anal. Chem.*, **21**:793 (1949).

18. LEVINE, W. S., ET AL. Direct Extraction-Pycnometer Method for Oil Content of Refinery Effluents. *Anal. Chem.*, **25**:1840 (1953).

19. MUSANTE, A. F. S. Rapid Semimicrodetermination of Oil in Refinery Waste Waters. *Anal. Chem.*, **21**:312 (1949).

20. MUSANTE, A. F. S. Determination of Oil in Refinery Waste Waters. *Anal. Chem.*, **23**:1374 (1951).

21. NOLL, C. A. & TOMLINSON, W. J. Fixing and Determining Oil in Feed Water and Boiler Water. *Ind. Eng. Chem.*, **15**:629 (1943).

22. PRINGLE, C. P. The Determination of Small Quantities of Oil in Water. *J. Soc. Chem. Ind.*, **60**:173 (1941).

23. WEBBER, L. A. & BURKS, C. E. Determination of Light Hydrocarbons in Water. *Anal. Chem.*, **24**:1086 (1952).

24. DANGL, F. & NIETSCH, B. Detection of Petroleum Products in Spring Waters. *Mikrochemie ver. Mikrochim Acta.* (Ger.), **39**:333 (1952).

25. HALSTRICK, JOSEF. Pollution of Drinking Water by Mineral Oils and Experiments to Detect Them by Fluorescence. *Arch. Hyg.* (Ger.), **128**:155 (1942).

26. HOLLAENDER, H. Determination of Oil in Boiler Water. *Seifen-Öle-Fette-Wachse.* (Ger.), **79**:546 (1953).

27. IWEKOWIC, H. The Fluorescence of Water in Filtered Ultraviolet Light as an Indication of Pollution. *Zeitschrift für Hygiene* (Ger.), **112**:54 (1931).

28. NIETSCH, BERTHER. Determination of Mineral Oil in Waters by Fluorescence. *Vom Wasser* (Ger.), **21**:186 (1954).

29. SIMARD, R. G., ET AL. Infrared Spectrophotometric Determination of Oil and Phenols in Water. *Anal. Chem.*, **23**:1384 (1951).

30. FEIGL, FRITZ. *Chemistry of Specific, Selective and Sensitive Reactions.* Academic Press, Inc., New York (1949), p. 597.

31. ROSEN, A. A. & MIDDLETON, F. M. Identification of Petroleum Refinery Wastes in Surface Waters. *Anal. Chem.*, **27**:790 (1955).

32. WEDGWOOD, PH. & COOPER, R. L. The Detection and Determination of Traces of Polynuclear Hydrocarbons in Industrial Effluents and Sewage. *Analyst* (Br.), **79**:163 (1954).

33. LUDZACK, F. S. & WHITFIELD, C. E. Determination of High Boiling Paraffin Hydrocarbons in Polluted Water. *Anal. Chem.*, **28**:157 (1956).

34. FOX, J. J. & MARTIN, A. E. Investigations of Infrared Spectra. *Proc. Roy. Soc. of London* (Br.), **A 157**:257 (1938).

35. FOX, J. J. & MARTIN, A. E. Investigations of Infrared Spectra. *Proc. Roy. Soc. of London* (Br.), **A 175**:208 (1940).

36. HEIGL, J. J., ET AL. Application of Infrared Spectroscopy to the Analysis of Liquid Hydrocarbons. *Anal. Chem.*, **19**:293 (1947).

37. IZYUROVA, A. I. Rate of Oxidation of Petroleum Products in Water Without Addition of Nitrogen. *Hyg. & Sanit.* (USSR), **7**:12 (1952).

38. ZOBELL, C. E., ET AL. Marine Microörganisms Which Oxidize Petroleum Hydrocarbons. *Bul. Am. Assoc. Petroleum Geol.*, **27**:1175 (1943).

Microphotometer Turbidity Analysis

W. R. Conley and R. W. Pitman

A contribution to the Journal by W. R. Conley, and R. W. Pitman, both with General Electric Company, Hanford Atomic Products Operation, Richland, Wash.

GREATLY increased demands for treated water have resulted from an increasing population, a rising standard of living, and growing industrial production. The per capita consumption of treated water was less than 50 gpd in 1900; today it is over 150 gpd. Technological advancements will further this trend until either supply or the limit of economic cost is reached.

The problem of providing enough additional pure water for our industrial and domestic requirements is becoming difficult because new sources are limited, and old ones are becoming more polluted. In those areas where additional water capacity is required, the most promising method of reducing capital costs of additional water treatment plants is to increase the unit treatment rate of existing or new plant components. Enlarging treatment capacity dictates the use of rapid and sensitive control methods to prevent any deterioration of water quality.

A water quality control method using a light-scattering microphotometer (Fig. 1) to measure the turbidity of filtered water is being used successfully at the Hanford Atomic Products Operation of the General Electric Company to reduce the risk of water impairment when the filter plants are operated at two to three times the normal flow rate. This unique method has resulted in production of highly purified water at more than double the original design capacity of the plant. It has made it possible to guarantee the quality of water filtered at 6 gpm per square foot with greater reliability than was possible with the conventional methods of 2½ gpm per square foot. The Hanford method consists in taking periodic sensitive turbidity analyses of each plant filter, usually at the beginning and end of the filter cycle. Because individual filters at the start and end of the filter cycle are very sensitive to slight variations in pretreatment conditions, treatment results can be detected on the individual filters long before the general plant effluent is seriously affected. Corrective action can thus be initiated before any serious breakdown in water quality occurs. The Hanford turbidity analysis method has a sensitivity of 0.01 ppm, and is so rapid that an operator can make a determination in 30 sec. The overall success of the Hanford method can be appreciated better when it is realized that filtered water of less than 0.05-ppm turbidity is being produced consistently with very short flocculating and settling times and a filtering rate of 6 gpm per square foot. Capital cost savings of several million dollars have resulted from the successful high-rate treatment.

In addition to the production usefulness of the microphotometer, the instrument makes it possible to speed up research and development work in filtered water turbidity.

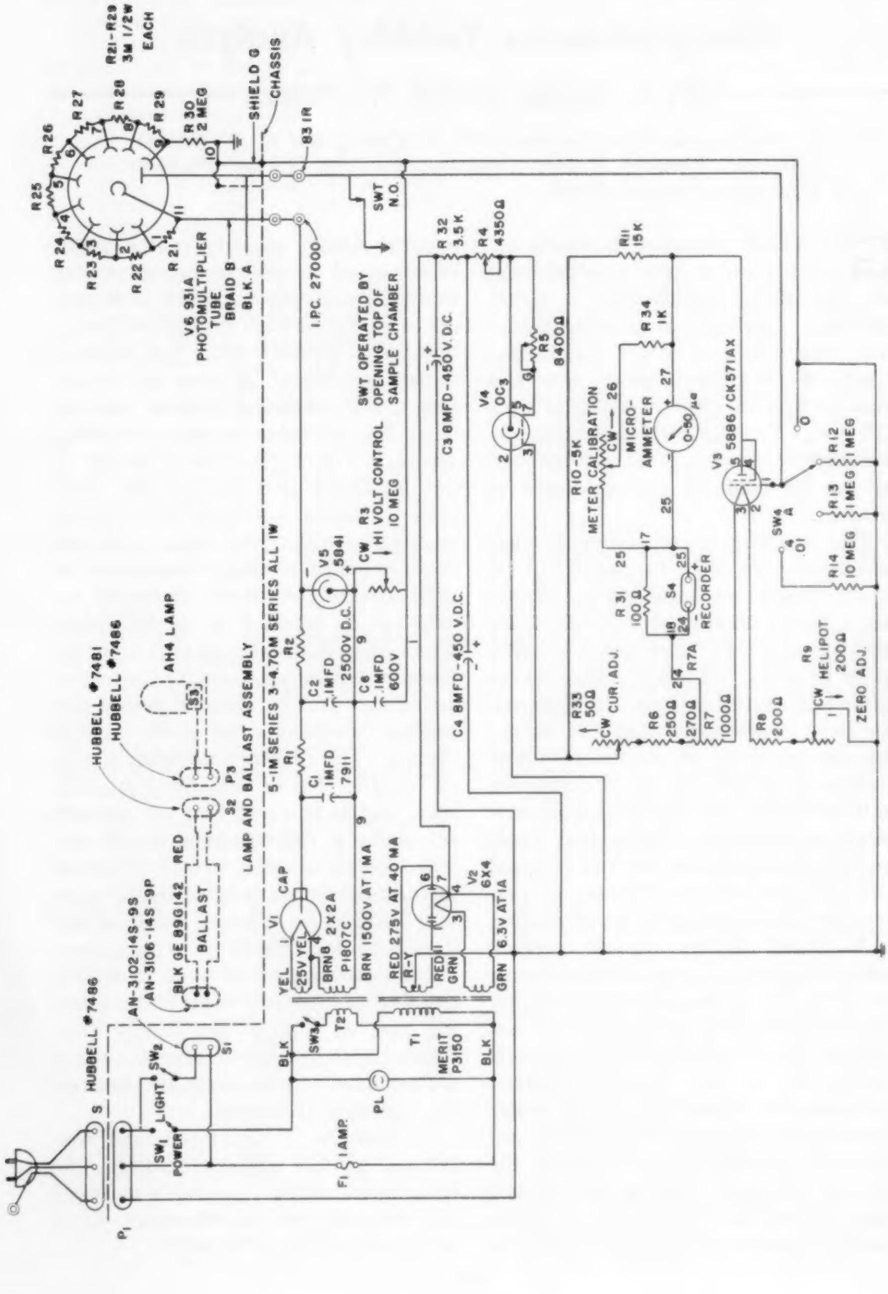


Fig. 1. Modified Light-scattering Photometer

The water works profession has been reluctant to adopt high-rate treatment, fearing that poor quality water would result. Although Baylis (*2, 3*), has shown that excellent quality water can be produced at filtration rate of 5 gpm per square foot, many states prohibit operation of filters at rates higher than 2 gpm per square foot. Public health groups responsible for suggesting legislation limiting filter flow rates of domestic water cannot permit higher filtering rates until they have positive assurance that water quality will not suffer. General acceptance of the use of higher water treatment rates can be attained only after significant experience and evidence is available to demonstrate that high flow rates can be maintained consistently without causing occasional production of poor quality water.

Evidence available from operation of the Hanford filter plant indicates that by improving the quality control methods and instruments, water quality has been improved significantly.

Modifying the Photometer

A number of standard turbidimeters were tried at Hanford, but none provided the desired sensitivity and speed. The Baylis cotton plug filter is sensitive but too slow for filter control purposes. The standard photometers are simply not sensitive enough.

In the effort to provide an instrument with the desired sensitivity coupled with ease and speed of operation, a photometer * used to measure reflected light was modified to meet filter plant control instrument requirements. The specific modifications are itemized in the appendix. Basically, the instrument utilizes a light source, a photocell and an amplifier. When a beam of light is focused on a water sample containing turbidity, some of the light is deflected. When a photocell is set at an angle from the straight light path, the scattered light can be measured. After extensive testing, an angle of 15 deg was selected as the most practical in providing the most sensitivity and reproducibility. The scattered light hitting the photocell creates a current which is amplified and calibrated in terms of turbidity.

Standardization and Sampling

The sensitivity of the microphotometer is so much greater than that of other instruments used in turbidity determination that standardization and sampling techniques must be given special attention.

The microphotometer is calibrated by using a suspension of bentonite having a known value of turbidity. The suspension of bentonite is prepared, allowed to settle, and the clearer portion decanted. The turbidity of this portion is determined on a spectrophotometer which has been previously calibrated as specified in *Standard Methods* (*4*). The relatively clear bentonite suspension is adjusted so that the turbidity is 10–20 ppm. The microphotometer amplification which can be changed in relative terms either to 1, 10 or 100 by changing a sensitivity knob to position 1, 2 or 3, is then set at the No. 1 position, and a reading is obtained with the bentonite suspension. A calibration curve is then drawn of turbidity in parts per million in relation to galvanometer deflection. When a sample containing low turbidity is analyzed, the sensitivity knob is turned to 3 or 4, the galvanometer position is read, the answer in terms of turbidity is obtained from the calibration curve, and the resulting num-

* Manufactured by the American Instrument Company, Silver Spring, Md.

Fig. 1. Modified Light-scattering Photometer

ber is divided by the sensitivity factor to determine the true turbidity of the sample. Obviously, then, the calibration method is indirect, in that the instrument is calibrated on the low sensitivity scale but used with the high sensitivity scale. This method was chosen because it was not possible to prepare reliable turbidity standards containing less than 0.1 ppm turbidity. It was found that very slight imperfections in the glass cuvettes used with the instrument cause large errors unless the precaution of positioning the cuvette in exactly the same manner each time was taken. A calibration curve must be prepared for each individual cuvette. It will be noted that the calibration method is slow and tedious. Consequently, there was developed for routine use a secondary calibration method which employs a permanent turbidity standard made by dispersing bentonite in liquid plastic and solidifying the mixture. The permanent standard is satisfactory when it is calibrated against the primary standard and the sample cuvette is not changed. If the sample cuvette is changed, a new curve must be prepared and the secondary standard must be recalibrated.

Sample methods must be carefully standardized to avoid gross error. The sample lines, for example, must be of thermoplastic resin or other corrosion resistant material, and the flow must not be changed, or the sample may be contaminated and erroneous conclusions drawn. Fresh samples should be used whenever possible although storage for a few hours in polyethylene bottles has been found to be reasonably satisfactory.

Plant Operation

The microphotometer is used to determine the turbidity of water taken from individual filters at specific time intervals. Work at Hanford shows that the chemical pretreatment of the water may be guided by the turbidity analyses from individual filters.

Samples from freshly washed filters are collected in polyethylene bottles and analyzed for turbidity. If the value of the turbidity is higher than normal plant optimum requirements, the alum feed is deemed to be insufficient and remedial measures are taken, If the samples are lower than the norm, the alum feed may be decreased without fear of producing inferior quality water.

Water samples from filters about to be backwashed are collected in polyethylene bottles and analyzed for turbidity. If the value of the turbidity is higher than normal, the filter runs are shortened or the activated silica feed is increased. If the samples are lower than the norm, the runs may be increased, or the activated silica decreased.

It has been found that floc appearance is not a reliable indication of adequate pretreatment of the water for filtration. Floc of decidedly inferior appearance often produces superior results at Hanford. Consequently, although some attention is given to the appearance of the floc, filter turbidity information is the most important factor used in deciding what the chemical feed rates should be, or when the filter run should be terminated.

Hanford methods are not conventional, but they have led to very high treatment rates, as well as to production of high water quality and low unit treatment costs. It is believed that Hanford methods may be found useful for any filter plant where water quality, water quantity, or water cost is of concern, and if adopted, will result in material increases in water production rates in existing plants.

Other Uses

Many of the turbidity particles in raw water are smaller than bacteria. Consequently, it may be inferred that complete removal of turbidity by filtration will also cause complete removal of bacteria. One might think chlorination would make it unnecessary to produce filtered water of high quality. Although chlorine is an efficient killer of coliform bacteria, however, there are certain spore formers, ameba, and worm eggs which are resistant to chlorine. It follows that efficient filtration of surface waters is highly desirable in domestic water production. The microphotometer makes it possible to monitor the quality of filtered water with sufficient speed and sensitivity to guarantee that any deterioration will be quickly detected.

Plants needing superior water for special manufacturing purposes will find the microphotometer useful as a research tool to evaluate various water treatment processes and materials. The effects of changes in chemical treatment, mixing, settling, and filtering can be evaluated more quickly and sensitively with the microphotometer than by any other known method. Laboratory and pilot plant investigations of mixing, coagulation, and filtration will be much more fruitful when the quality of the effluent can be quickly and accurately established. It is believed that the instrument will become a standard for all groups interested in filtered water of superior quality.

Acknowledgment

M. C. Lambert, Engineering Department, General Electric Company, Hanford Atomic Products Operation, first suggested the use of the microphotometer for water turbidity measurement, and carried out the preliminary laboratory work.

References

1. Oster, Gerald. *Anal. Chem.*, **25**:1165 (1953).
2. Baylis, John R. Continued Tests on High-Rate Filtration. *Pure Water* **6**: (Aug. 1954).
3. Baylis, John R. Experience With High-Rate Filtration. *Jour. AWWA*, **42**:687 (Jul. 1950).
4. *Standard Method for Examination of Water and Sewage.* APHA, AWWA, & FSIWA, New York (10th ed., 1955).

APPENDIX

Microphotometer Modifications

The Light-scattering Microphotometer was modified as follows:

1. A cuvette $1\frac{1}{2}$ in. in diameter and 2 in. in length was made of clear pyrex glass standard wall tubing, and centered on a $1\frac{3}{4}$-in. square metal base.
2. The stage of the instrument was fitted with a $1\frac{3}{4}$-in. square hole to position the cuvette accurately.
3. All filters were discarded except the heat absorption filter. The filter slots were sealed.
4. The photomultiplier was raised 1 in. off the instrument floor and all electrical connections to it were waterproofed and shielded.
5. Various resistances were replaced with resistances in series.
6. The photomultiplier sights were set at a 15 deg angle to the straight beams.
7. A $1\frac{1}{2}$-in. by $1\frac{1}{2}$-in. clearly polished solid acrylic resin cylinder was impregnated homogenously with a small amount of bentonite to be used as a reference. The value of the reference was determined by comparing it to a known bentonite turbidity solution which had been calibrated by comparing the bentonite to a known silica standard on a spectrophotometer. The standardization of the microphotometer was made on its lowest amplification.

Water Resources Problems in Virginia

William M. Johnson

A report presented on Nov. 4, 1955, at the Virginia Section Meeting, Roanoke, Va., by William M. Johnson, Partner, Wiley & Wilson, Consulting Engr., Lynchburg, Va.

VIRGINIA and much of the Eastern United States have, for the past 5 or 6 years, experienced periods of extreme drought. In 1954 Governor Stanley appointed a water resources committee to operate under the Virginia Advisory Legislative Council. This committee was charged with gathering factual information and preparing a report on water resources and their uses. The committee could pass no laws, but only recommend measures, so that regulations could be developed by the state legislature.

The water resources committee consists of thirteen members: some are members of the state legislature, with the remainder representing industries, small and large municipalities, agriculture, and engineering interests. All zones of conflicting interest are thus covered.

The committee decided to hold public hearings at strategic points over the entire state, from Norfolk to Wytheville, and from Alexandria to Danville. They were well advertised in advance and well attended.

With the exception of the Richmond hearing, interests represented were principally agricultural and municipal. At each hearing it was pointed out that the committee met to hear the water problems of those present, and not to offer or propose any legislative plan. Each person attending a hearing was given an attendance card to fill out with his name and business interest. He was then called to state his case. This method was successful in that each person became a part of the program and entered wholeheartedly into the discussions. Hearings quickly brought out the distinct conflicts between agriculture, industry, and municipal water demands—conflicts which have increased with the growth of these interests. Agriculture consumes water while industries and municipalities return the used water as treated or untreated industrial of sewage waste, usually into the course whence it was drawn.

Agricultural Needs

The more intense the agricultural development, the greater is the use of water. In past years, a farmer could realize 20–25 bu corn per acre while relying only on rainfall. Today, corn exceeds 50–60 bu per acre, and many crops top 100–125 bu. Water needs are correspondingly greater, especially during peak seasons. Rainfall and soil water cannot meet this high demand, and supplemental water must be provided by irrigation. This condition also holds true for tobacco, forage crops, pasture land, and fruit and vegetable production.

It was interesting to note that practically every case of reported supplemental irrigation used in productive agriculture had proved profitable. Sources of irrigation water were from streams, farm ponds storage, and deep wells. More than 700 irrigation projects were expected to operate during

the summer of 1955, each with an average water consumption of approximately 700 gpm.

The discussions and hearings also brought out the fact that, in most areas where irrigation is necessary, flood conditions exist at some time during the year. A review of rainfall and runoff records, together with agricultural and industrial needs, indicated that rainfall distribution and runoff conservation were the problems. Future water requirements could be met if regulation and storage could provide constant, minimum stream flow.

Industrial and Municipal Needs

Almost every industry seeking a new location looks first to an adequate source of water supply needed in manufacturing processes, in steam production, and in heating and cooling requirements.

In municipalities, the per capita water consumption has increased rapidly since the war with the addition of labor-saving devices in homes. Thus it is found that, during the season when supplemental irrigation is necessary for farming, use of water in homes and commercial establishments is also at the peak. Normally industrial demand is fairly constant throughout the year.

Riparian and Recreational Needs

The deficiencies of the present riparian doctrine in meeting existing problems was brought out in each hearing; the general common law being that a riparian owner is entitled to the use of the minimum flow of water in the stream adjacent to his property.

In discussions on the uses of water, recreational needs were not considered among the conflicting interests. These needs, however, concern all parties involved and all segments of society. There are approximately 58,500 acres of public fresh-water fishing available in the Commonwealth of Virginia. During 1954, 425,000 fresh-water fishing licenses and 501,000 fishing and hunting licenses were sold. To date, the commission on game and inland fisheries has stocked approximately 478 streams of public fishing waters. This is in addition to the private farm ponds built for irrigation or recreational use. The number of these ponds, developed on private property for private use, is growing so fast that it is impossible to keep up with the inventory of such improvements. One needs but to fly over the lands of the commonwealth to realize the vast number and extent of such ponds.

Conclusion

Each subcommittee of the committee on water resources has prepared a report on its respective subject based on the factual information obtained from published records and the hearings held throughout the state. These have been combined in a general report on water resources. It is realized by the committee that this question is so extensive and so involved, that it is impractical to reach a solution or an answer to the question of riparian rights, distribution of water to conflicting interests, and conservation measures, within the period which has elapsed since this committee was appointed. The first measures to be proposed to the legislature will deal with scaling of unused flowing artesian wells, and will encourage the capture of flood waters by legalizing the ownership of the person capturing the water.

It is the general feeling of the committee, based on records of rainfall, runoff, and future requirements, that sufficient water will always be available to all Virginians, but that conservation of flood water is important for all parties.

Discussion

Oral H. Hert and Charles H. Bechert

Oral H. Hert, Special Projects Engr., State Board of Health, Indianapolis, Ind.; and Charles H. Bechert, Director, State Div. of Water Resources, Indianapolis, Ind.

Indiana and many eastern states have water resource problems similar to Virginia's. State water resources development and legislation, aimed at safeguarding these resources, are commanding widespread interest.

Water studies are underway in at least 29 states. Nearly all of these reported some action pertaining to water and water rights during their recent legislative sessions.

The use of water for irrigation is developing rapidly in the eastern states. Estimates released by the US Department of Agriculture indicate that irrigated acreage will double within the next 20 years. In Indiana, this acreage increased from 5,000 to 35,000 in the years between 1950 and 1955.

Municipal water consumption is increasing with urban population and per capita use. The average daily consumption in Indiana increased from 198.5 mgd in 1940 to 333.2 mgd in 1954. During this period, the urban population increased at the rate of 51,000 per year, with a water consumption increase averaging 2.3 gal per capita.

An important use of water which should not be overlooked is the dilution of treated sewage and wastes. Domestic and industrial usage is not primarily for drinking purposes. Available for reuse, therefore, is 75–90 per cent of this water. Treatment, however, does not return this water in its original quality, so that in some areas, dilution water is required to maintain satisfactory conditions for the downstream uses.

Shorter working hours have expanded recreational activities. Public funds have been authorized for development of water resources for recreation. The social aspects of our economy requires that this be considered a legitimate use.

Further clarification is desirable on "the deficiencies of the riparian doctrine . . ." as presented in the report. The general rule of riparian rights, as explained by C. R. Busby, in a paper presented at the 1955 American Farm Bureau Federation meeting, is that each riparian owner is entitled to use the stream for his own needs, but must be reasonable in relation to like rights of all other riparian owners. Riparian rights do not include use by commercial livestock or for irrigation. Most of the eastern states are currently using this general rule, with some local exceptions.

The Indiana water resources study committee, composed of thirteen members, consists of members of the state legislature, representatives of various departments of state government with varied interests in water uses, and three members of the agricultural staff of Purdue University. Subcommittees representing all areas of water use have been appointed to implement the work of the study committee.

The task of the Indiana committee is to conduct a survey of water rights and water management laws, and report its findings to the Indiana General Assembly. The primary goal is not necessarily the regulation of water use, but rather the development and expansion of the beneficial uses of our water resources.

Sea Water Intrusion in California

Harvey O. Banks, Raymond C. Richter, and James Harder

A paper presented on Oct. 27, 1955, at the California Section Meeting, Sacramento, Calif., by Harvey O. Banks, Director, State Dept. of Water Resources, Sacramento, Calif., Raymond C. Richter, Supt. Engr. Geologist, Calif. Dept. of Water Resources, Sacramento, Calif., and James Harder, Asst. Research Engr., Univ. of Calif., Berkeley, Calif.

PRIOR to 1900, utilization of ground water supplies was relatively unimportant in California. Rapid development since the turn of the century has created many serious problems, including overdraft and sea water intrusion. Since 1940, long-continued draft on the coastal ground water basins, a protracted period of drought in Southern California, and increasing agricultural, municipal, and industrial demands, have lowered ground water level elevations below sea level along the seaward margins of many ground water basins, thus reversing the natural seaward hydraulic gradient. As a result of this overdevelopment, extensive damage from sea water intrusion has already occurred in numerous ground water basins adjacent to the coast, causing large economic losses. Unless means of prevention and control are undertaken in the near future, further widespread deterioration of ground water supplies will occur in the areas already affected. There are, in addition, a large number of ground water basins not yet affected, whose geologic and hydrologic conditions suggest that they too will suffer from intrusion of sea water.

Extent of Intrusion

Sea water intrusion was first noted in California about 1906 along the bayward margin of Mission Valley in San Diego County. As of 1955, studies by the California Division * of Water Resources (*1*) indicated that sea water intrusion was a critical water quality problem in nine coastal ground water basins. In these basins (*see* Fig. 1), as a result of excessive extractions of ground water, the water and pressure levels along the seaward margins have been drawn down below sea level for considerable periods of time, and a landward hydraulic gradient exists over all or part of the basin. Ground waters are high in chloride ion concentration in certain areas along the coast, and chloride waters are moving inland under the reversed hydraulic gradient.

The most serious invasion to date has occurred in the West Coast Basin (No. 9) † in Los Angeles County where intrusion was first noted in 1921, and in the Coastal Plain (No. 10). Other critical areas include: San Luis Rey Valley (No. 11); Oxnard

* Now State Dept. of Water Resources.

† This and other numbers in this paragraph refer to the keyed sites in Fig. 1.

Plain (No. 8); Salinas Valley (No. 5); Pajaro Valley (No. 4); Santa Clara Valley (No. 3); Napa-Sonoma Valley (No. 2); and Petaluma Valley (No. 1). A detailed inventory of the status of encroachment in each of the nine critical areas is presented in Table 1.

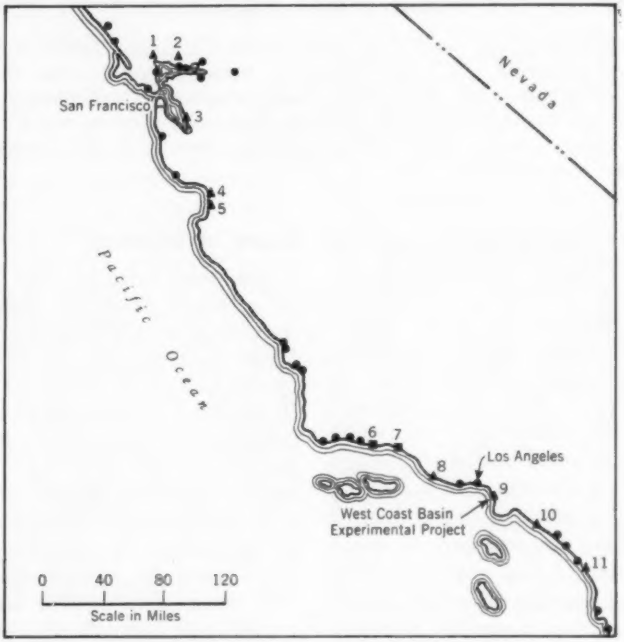


Fig. 1. Areas of Sea Water Intrusion in California

Key: ▲—areas of known sea water intrusion in which landward hydraulic gradient has been established; ●—areas of degraded coastal ground waters in which source of degradation has not been definitely established; ■—areas of threatened sea water intrusion in which landward hydraulic gradient has been established but where there exists no present evidence of degradation of ground water. Three areas of the second type in Northern California are not shown. The numbered areas are referred to in the text.

An immediate and serious danger of encroachment exists to the ground water supplies in Goleta and Carpinteria basins in Santa Barbara County (Fig. 1: No. 6 and 7). Ground water levels are below sea level, and a landward hydraulic gradient slopes inland from the coastal areas. As of 1955, however, coastal ground waters pumped from wells along the coast did not show high chlorides. In addition to these eleven basins there are 33 basins in which ground waters in the coastal segment are high in chlorides, but evidence as to source is not as conclusive as for the nine basins already men-

tioned. It is presumed that degradation in these 33 basins is caused by sea water intrusion. It could, however, be caused, at least in part, by other factors, including: [1] upward or lateral movement of brackish or saline connate waters; [2] interchange between aquifers of waters of differing mineral quality through natural breaks in silt and clay layers, or through improperly constructed, defective, or abandoned wells; [3] downward movement of perched waters of poor quality; [4] inflow or percolation of water from highly mineralized springs and streams or both; [5] adverse disposal of industrial wastes and sewage; and [6] adverse salt balance.

There are, in addition, approximately 100 other coastal ground water basins in which there is now some development of ground water, and in which sea water intrusion may become a problem if the supply is overdeveloped. There are approximately 120 coastal basins in which at present there is no development of ground water. A potential threat of intrusion exists in these undeveloped basins but encroachment is restrained for the present because ground water levels in the coastal areas are at or above sea level and a seaward hydraulic gradient exists over the entire basin.

Conditions in Coastal Basins

Ground water supplies in coastal basins in California are stored mainly in the larger alluvium-filled valleys. These valley fill areas, which are of variable depth, are composed of unconsolidated alluvial-fan, flood plain, and shallow marine deposits. The princi- extensive sand and gravel deposits in the large coastal plain areas in Orange, Los Angeles, Ventura, Monterey, Santa Clara, Napa, and Sonoma counties. These deposits extend to many hundreds of feet below sea level along the coast, and may extend for some distance beneath the floor of the Pacific Ocean or under San Francisco Bay.

In addition to the extensive ground water supplies in the coastal plain areas, limited quantities of ground water occur in numerous shallow alluvium-filled valleys along the coast. These small valleys, and the several buried channels filled with sand and gravel—such as the Gaspur and Talbert water-bearing zones in the Coastal Plain of Los Angeles and Orange counties, and the "180-ft aquifer" in Salinas Valley—represent buried coarse-grained deposits in ancestral channels of Pleistocene streams. The base of these old buried stream channels adjacent to the coast is quite shallow, generally 150–200 ft below sea level. In a few isolated areas along the coast, the base approaches 300 ft below sea level.

Geologic evidence indicates that the water-bearing deposits along the seaward and bayward margins of these coastal ground water basins either may be in direct contact with the ocean or bay floor at the shoreline, or may extend beneath the floor as a confined pressure aquifer in contact with sea water at some distance offshore. Numerous submarine canyons are incised into the continental shelf, resulting in exposure of the fresh water-bearing sediments to sea water at points in these canyons closer to the shoreline than elsewhere.

Before man's development of the ground water resources, a seaward hydraulic gradient existed in all the ground water basins along the coast.

TABLE 1

Sea Water Intrusion in Nine Critical Areas in California

Key*	Basin or Valley	Max. Inland Position of Encroachment *miles*	Date	Max. Inland Position of Pumping Trough *miles*	Date	Inland Distance Water Levels Below Sea Level *miles*	Date	Max. Chloride *ppm*	Date
1	Petaluma Valley (Sonoma County)	0.7	fall 1954	no data	—	0.9	fall 1954	362 3,390†	May 1954
2	Napa-Sonoma Valley (Napa & Sonoma counties)	0.7	fall 1954	no data	—	‡	—	1,580	summer 1954
3	Santa Clara Valley (Santa Clara & Alameda counties)								
	Upper aquifer	4.5	fall 1950	6	summer 1951	7	summer 1951	1,000+	summer 1954
	Lower aquifer	1.0	—	4	—	7	summer 1951	350+	winter 1953–54
4	Pajaro Valley (Monterey County)	spotty occurrence	summer 1955	1.0	summer 1947	4.0	summer 1947	620	summer 1955
5	Salinas Valley (Monterey County)								
	180-ft aquifer	2.5	summer 1954	6	summer 1954	8+	summer 1954	1,000	summer 1954
	400-ft aquifer	1	—	no data	—	5	summer 1954	354	summer 1954
8	Oxnard Plain (Ventura County)	1.1	December 1954	3–4	November 1951	7–8	November 1951	11,375	February 1950
9	West Coast Basin (Los Angeles County)	2	spring 1955	3–7	spring 1953	11	spring 1953	18,000	fall 1955
10	Coastal Plain (Orange County)	3	fall 1954	6	fall 1955	11	fall 1955	4,203	fall 1951
11	San Luis Rey Valley (San Diego County)	0.8–1.6	September 1955	no data	—	no data	—	7,500	September 1955

* Refers to location in Fig. 1.
† In tidal area.
‡ Local pumping holes only during summer months.

The seaward extension of the coastal aquifers was saturated with fresh water or intermingled with saline and brackish water. Disposal of excess fresh water occurred in areas cut by submarine canyons, or where the aquifers outcropped on the ocean or bay floor. As shown in laboratory and model studies at the University of California (*2*), even under such conditions a saline wedge extended inland a relatively short distance (Fig. 2). In these studies, an equation was derived relating the seaward hydraulic gradient, the flow of fresh water, aquifer characteristics, and the wedge length. Using the nomenclature of Fig. 2, the seaward flow per unit length of coastline is:

$$q = \frac{(S-1)MT}{2L}$$

A second important principle for understanding sea water intrusion is also illustrated in Fig. 2. According to the Ghyben-Herzberg principle, the fresh-water piezometric surface must lie a distance h above sea level equal to $(S-1)H$, where H is the distance below sea level to the toe of the wedge, in order to prevent the salt water from intruding further inland. It is interesting to note that, whereas the distance h depends on the depth of the aquifer below sea level, the fresh water flow is completely independent of this distance, depending instead on the thickness of the aquifer, M. This principle and the above equation were experimentally verified in a special model aquifer constructed at the University of California at Berkeley. It should be emphasized that the equation describes conditions at equilibrium, when the salt water wedge is held stationary.

From these principles it can be deduced that a certain quantity of water must be allowed to leak seaward merely to prevent the intruding wedge from moving further inland. As an example of the magnitude of this flow, it is estimated that a seaward flow of approximately 4,000 acre-ft per year is required to stabilize the saline wedge at a length of 4,000 ft along the 20-mile coastal segment of the West Coast Basin in Los Angeles County. This assumes an aquifer thickness of 100 ft, and a permeability of 9 ft per hour, a figure given for the Silverado water-bearing zone underlying the West Coast Basin experimental project site to be described later. If the wedge can be allowed to move inland for a wedge length of 8,000 ft, the leakage would accordingly be reduced to 2,000 acre-ft per year.

Methods of Control

In the light of present knowledge and experience there appear to be five possible methods of control for the prevention and control of sea water intrusion. These methods include:

1. Raising of ground water levels to or above sea level by reducing or rearranging the pattern of pumping draft
2. Direct recharge of overdrawn aquifers to maintain ground water levels at or above sea level
3. Maintenance of a fresh-water ridge above sea level along the coast
4. Construction of artificial subsurface barriers
5. Development of a pumping trough adjacent to the coast.

Any comprehensive program for the control of sea water intrusion should require the enforcement of satisfactory minimum standards of well construction and abandonment to prevent

degradation of ground waters by migration of water from one water-bearing zone or another, as well as to prevent the downward movement of saline surface and perched waters.*

It is beyond the intent and scope of this article to discuss in detail any method other than maintenance of a fresh-water pressure ridge. In evaluating the economic feasibility of these procedures, the following factors, among others, must be taken into account: the cost of supplemental water, including the expense of any necessary treatment; the cost of spreading or injection; the value of storage capacity in the basin; the cost of pumping water from the basin; and, in some instances, the value of the ground water basin as a source of emergency supply. The total net costs of preventing sea water intrusion by any means other than method No. 1 above must be balanced against the cost of decreasing extractions from the basin to the necessary extent and using supplemental water directly on the surface.

As far as is now known, method No. 1 would probably always be effective in any coastal ground water basin, irrespective of its size. For full effectiveness, this method requires the determination of water rights and subsequent control of extractions, as well as an available source of supplemental water to offset the reduction in use of ground water. Methods No. 2 and 3 would be physically feasible if a supplemental water supply of sufficient quantity and of a suitable mineral quality were available.

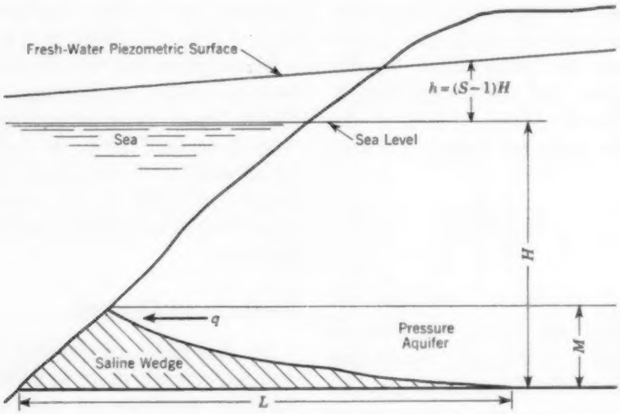


Fig. 2. Saline Wedge Extending Through Pressure Aquifer

Key: q *is the seaward fresh water flow per foot of ocean front;* S *is the specific gravity of sea water;* M *is thickness of aquifer, down to the lowest depth which must be protected;* T *is aquifer transmissibility for a 100 per cent hydraulic gradient; and* L *is length of sea water wedge from ocean outlet to the toe.*

* Perched waters are bodies of shallow, free ground water overlying the principal fresh water-bearing aquifer.

In both methods No. 2 and 3, sufficient fresh water must be supplied to equal the total overdraft, including amounts which are necessary to hold back the saline wedge, or else the intrusion will be merely slowed down. In method No. 3, sufficient fresh water must be supplied to the principal water-bearing deposits along the coast to take the place of the salt water that will move inland to replace fresh-water extractions. As shown by the University of California study (*2*), if the fresh water recharge through coastal injection wells fails to make up the overdraft, salt water continues to flow around and between the wells and will probably render the injected water unfit for use. On the other hand, if under method No. 2, water levels are held above the safe level throughout the ground water basin, the usable storage capacity of the basin is decreased. A combination of methods No. 2 and 3, in which the recharge is applied some distance inland from the known limits of intrusion, might, in some circumstances, offer some advantages. The recharge rate would not need to be as continuous as under method No. 3, as there would still be a region oceanward from the recharge site in which the saline wedge could be moved back and forth. This might constitute a storage capacity of considerable magnitude. Further study would be required to determine whether the average seaward flow required to prevent a net inland movement of salt water would be higher than under the steady state. Under such a technique, water levels further inland could still be allowed to drop below sea level.

Method No. 4 appears to offer many advantages, particularly for the numerous shallow alluvium-filled valleys, as a supplemental water supply might not be required and determination of water rights is not absolutely necessary. The cost, however, would probably be high. Method No. 5 might be applied temporarily where encroachment is far advanced, until a more permanent control procedure could be applied. The University of California study has shown that contrary to previous estimates, there need be no large loss of fresh water in the pumping-trough method. Essentially, a sea water wedge forms inland from the pumping wells and the fresh-water flow over this wedge is given by the same formula as before. In this case the wedge length is measured inland from the pumping wells instead of from the ocean outlet. Because there would no longer be a source of sea water to replace inland extractions, water levels would generally drop more rapidly than before.

Previous Investigations

For more than two decades, the California Division of Water Resources has been investigating sea water intrusion in the state. The program was greatly accelerated in 1950, following passage of an act directing the division to ". . . investigate conditions of the quality of all waters within the state, including saline waters, coastal and inland, as related to all sources of pollution of whatever nature. . . ." Subsequent appropriations have implemented this investigational program. In December 1950, the division released a preliminary report on the status of sea water intrusion in California (*4*), prepared at the request of the State Water Pollution Control Board.

In view of the serious nature of the problem of sea water intrusion as dis-

closed in the division's report (*4*), the state legislature during its 1951 session appropriated the sum of $750,000 to the Water Resources Board for an experimental program to determine criteria for the prevention and control of sea water intrusion into ground water basins. As discussed later, this experimental program, prepared by the Division of Water Resources (*5*), which serves as the technical staff for the board, centered around the determination of factors necessary to apply the theories of the pressure ridge and reduction of permeability to a workable program for prevention and control of sea water intrusion. In order to implement this comprehensive investigational program, the board contracted with the Los Angeles County Flood Control District for construction and operation of a large-scale experimental project in the vicinity of Manhattan Beach, Los Angeles County, and with the University of California and the USGS for certain basic laboratory investigations. As a result of these cooperative studies, several detailed re-

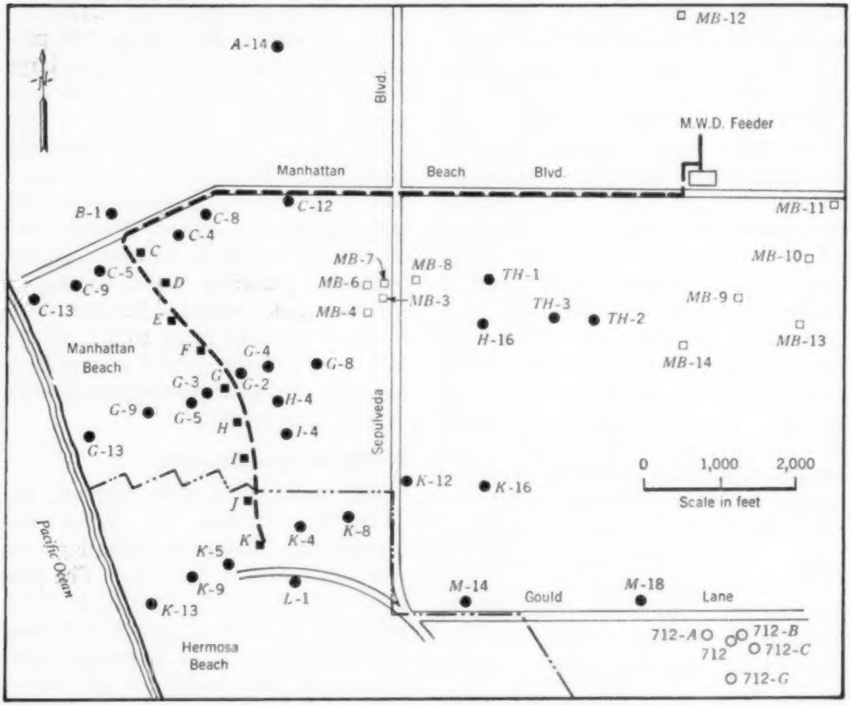


Fig. 3. Recharge Project Wells and Supply Line

Key: ■—project recharge wells; ●—project observation wells; □—Manhattan Beach wells; ○—California Water Service Co. wells; the broken line indicates the supply line. (M.W.D. denotes "Metropolitan Water District.")

ports have been prepared and submitted to the State Water Resources Board (*2, 6, 7, 8*). In addition to the above mentioned formal publications, numerous reports on the problem of sea water intrusion in California have appeared in various technical journals (*9–14*).

West Coast Basin Project

As a part of the investigational program of the Water Resources Board to determine design criteria and develop plans for the control of sea water intrusion, a large-scale experiment was conducted along the coast near Manhattan Beach, Los Angeles County, (Fig. 1 and 3). The experimental project was constructed and operated by the Los Angeles County Flood Control District under contract with the board and under supervision of the Division of Water Resources. State funds were exhausted in December 1953; subsequently, the district has continued operation on a reduced scale, using its own and local funds.

This project was designed to obtain experimental data and to determine the feasibility of control of sea water intrusion by the creation and maintenance of a pressure ridge in a confined coastal aquifer by injection of fresh water through wells. Confined aquifers are common in the coastal ground water basins of California; in fact, most instances of sea water intrusion have occurred in such aquifers. Although there was some antecedent experimental information pertaining to recharge by injection through wells,

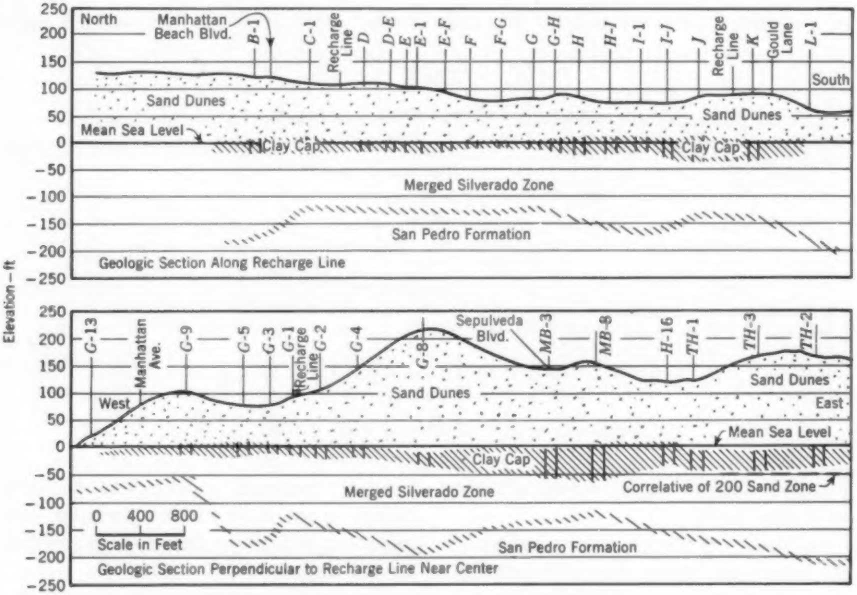


Fig. 4. Geologic Section in Recharge Line Area

these data were incomplete and sometimes conflicting.

The choice of the site for the experimental project was based on the following considerations:

1. Sea water had intruded into the main Silverado water-bearing zone underlying the area to a considerable distance inland.
2. The Atchison, Topeka, and Santa Fe Railroad provided right of way for the project facilities without cost.
3. A source of suitable injection water was available in the vicinity.
4. The Silverado water-bearing zone is a confined pressure aquifer suitable for the desired experiments utilizing injection wells.
5. Wells to the existing piezometric surface could be comparatively shallow.
6. Depth below sea level to the bottom of the aquifer at the site is less than further inland.
7. Local interests desired to reclaim as much of the aquifer underlying the test site as possible.

The test site is underlain by the relatively shallow depths by the confined merged Silverado water-bearing zone in the San Pedro formation of Pleistocene age (Fig. 4). The Silverado zone is confined here by a clay cap except in the area immediately adjacent to the beach. The lower limits of the Silverado zone are bounded by relatively impermeable silts and clays of the San Pedro formation at a depth of approximately 110 ft below sea level.

Heavy draft on the coastal segment of the West Coast Basin starting at the turn of the century resulted in general lowering of the water table below sea level throughout most of the area. By 1932 the entire coastal reach had been intruded by saline water. Increasing heavy draft since 1932 has caused continued landward movement of the saline front toward the axis of the pumping trough in the eastern portion of the basin.

The initial experimental project involved nine 12-in. wells spaced at 500-ft intervals and drilled by the cable tool method. One of the wells was gravel packed; the other eight, which were not, had casing perforated in place. Thirty-six 8-in. observation wells were installed. Pumping tests were run on injection wells to determine permeability and transmissibility

TABLE 2

Recharge Injection Rates (see Fig. 4)

Date	Injection Rates—*cfs*									
	Wells									Total
	C	*D*	*E*	*F*	*G*	*H*	*IA*	*J*	*K*	
2/12/53	0	0	0	0	0	0	0	0	0	0
3/10/53	0	0	0	0	0.75	0	0	0	0	0.75
6/15/53	0	0	1.05	0	0.54	0	0.36	0	0.48	2.43
6/24/54	0	0.41	0.45	0.59	0.64	0.70	1.13	0.55	0.30	4.77
2/10/55	0	0.32	0.38	0.55	0.74	0	1.43	0.32	0.62	4.36
9/22/55	0.30	0.31	0.55	0.46	0.77	0.51	0.95	0.40	0.57	4.77

of the Silverado water-bearing zone. The initial installation was completed by the construction of 12,098 ft of 20-in. diameter steel pipeline and appurtenances to provide water to the recharge line, plus the necessary chlorination facilities (Fig. 3).

Construction was initiated in January 1952, with the commencement of well drilling. This phase was completed 1 year later. Construction of the pipeline was started in the fall of 1952 and completed in February 1953, when well injection was commenced. As the field experiment proceeded, it became necessary to add eighteen 2-in. and four 4-in. observation wells, and to replace one nongravel-packed recharge well with a gravel-packed well. Metropolitan Water District water used for injection was filtered and partially softened by the zeolite process.

A detailed description of the operation of the West Coast Basin Experimental Project is presented in the final report of the Los Angeles County Flood Control District (*6*), and in a technical paper by Laverty and van der Goot (*12*). Only a brief description of the injection operations and summary of findings will be presented here.

Recharge Operations

Recharge was initially commenced in Well *G* at the center of the recharge line in February 1953, at a rate of 0.5 cfs (Fig. 5). A small pressure cone, centered at the well, was formed on top of the large body of saline water which was moving landward under influence of a reversed hydraulic gradient. The pressure effect in Well *G* extended almost instantaneously in all directions, and within a few hours was noted in observation wells 1,000-ft distant from the well. Injection was initiated and maintained at varying

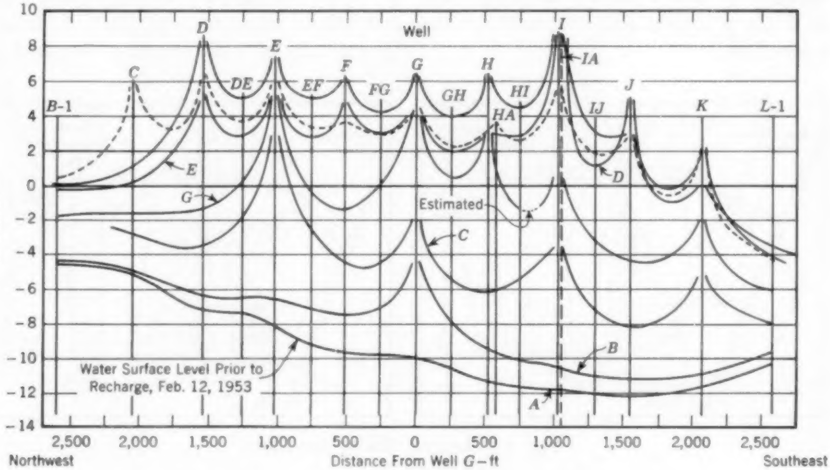


Fig. 5. Water Surface Profile Along Injection Line

A—*Feb. 12, 1953;* B—*Mar. 10, 1953;* C—*Jun. 15, 1953;* D—*Jun. 24, 1954;* E—*Feb. 10, 1955;* F—*Sep. 22, 1955;* G—*Jul. 31, 1953. See Table 2 for injection rates.*

rates in adjacent wells north and south of Well *G*, resulting in overlapping pressure cones which formed a pressure ridge along the recharge line with alternate peaks and valleys. By April 1954 sufficient water had been injected to raise all of the valleys to an elevation above sea level. This pressure ridge has been maintained since 1954 with minimum elevation of the valleys between injection wells averaging 3–4 ft above sea level. A well spacing of 500 ft and a recharge rate of 5 cfs per mile was required for the operation.

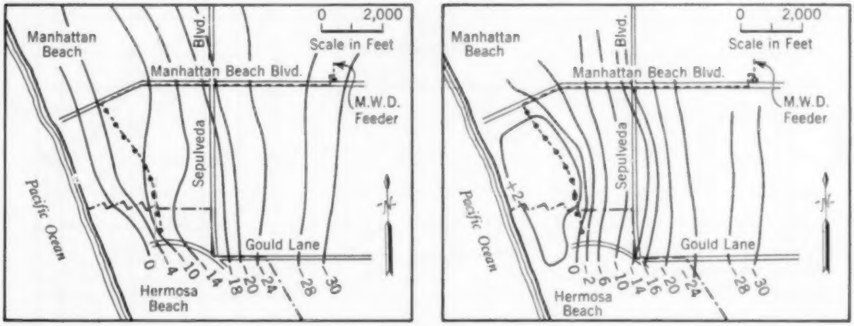


Fig. 6. Ground Water Contours

Figure on the left represents ground water contours on Feb. 20, 1953. Figure on right represents contours after injection on Jun. 24, 1953.

Configuration of the established pressure ridge along the recharge line is well shown in Fig. 6. A fairly steep hydraulic gradient exists just landward from the injection line, indicating that a large portion of the injected water is flowing landward along the hydraulic gradient toward the axis of the artificial pumping trough in the Silverado water-bearing zone. Critical areas along the recharge line are the valleys between the injection wells. Configuration of the isochlors along the injection line is well shown in Fig. 7, where long streamers of low chloride water are moving landward over high saline waters. Salinity-time histories of several observation wells (Fig. 8) indicated that chloride contents in some of the internodal areas remained high, even though the artificial piezometric surface was at an elevation above sea level; this theoretically would have displaced all saline water to the base of the Silverado zone.

Well acceptance rates during the period of operation varied. A maximum rate of 1.86 cfs was obtained in a gravel-packed well for several hours. In general, sustained acceptance rates averaged 1.0 cfs in gravel-packed wells and 0.5 cfs in nongravel-packed wells with 27–50-ft injection heads. Chlorination rates of 5–10 ppm were required to maintain these injection rates.

Operation of the pressure mound on top of a wedge of intruding saline water resulted in gradual movement of saline water inland into the basin. This movement at the test site was

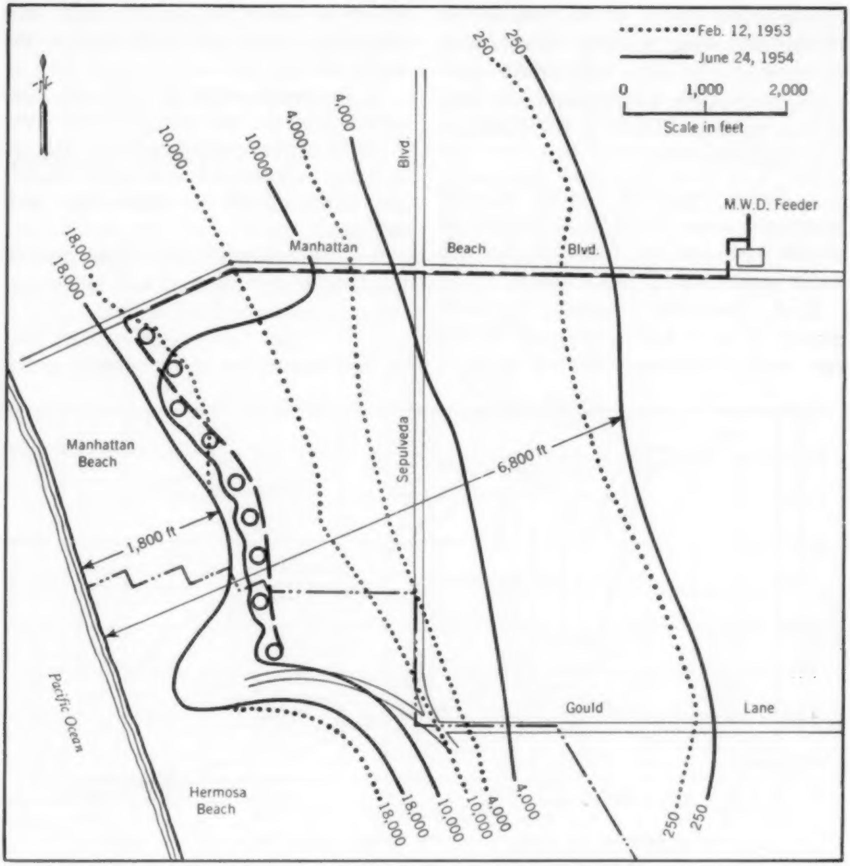


Fig. 7. Isochlors Before and During Recharge

The isochlor values are in parts per million. (M.W.D. denotes "Metropolitan Water District.") The inland advance of the saline front is relatively minor.

confirmed by the model studies performed by the University of California at Berkeley (*2*). An idealized section depicting the formation of this "saline wave" and overriding fresh water is shown in Fig. 9. Landward movement of the saline water was variable along the front, attaining a maximum inland movement of 1,000 ft for the period June 1954–April 1955 (Fig. 7). Maximum effect of this saline wedge on inland pumping wells has not been established because of large distances involved and short period of time since the inception of injection.

Findings

The investigational work performed at the West Coast Basin Experimental Project for the prevention and control

of sea water intrusion has culminated in the following findings which may be applicable to areas with similar geologic, hydrologic and topographic conditions to those found at the Manhattan Beach test site:

1. Prevention and control of sea-water intrusion could be accomplished at the test site by recharge through wells with treated fresh water.

2. A pressure mound, approximately 9–14 ft was established at the site with a recharge rate of about 5 cfs per mile and a well spacing of approximately 500 ft. Density of saline and fresh waters and aquifer thicknesses were such that the required elevation of the induced piezometric surface at the internodes, midway between the injection wells, were 3–4 ft above sea level.

3. Well spacing is a function of aquifer thickness, permeability and pre-recharge landward hydraulic gradient. With recharge wells as constructed at the site ranged from more than 1.0 cfs in gravel-packed wells to 0.5 cfs in nongravel-packed wells with attendant heads 27–50 ft within the well casings.

4. Recharge rates in wells as constructed at the site ranged from over 1 cfs in gravel-packed wells to 0.5 cfs in nongravel-packed wells with attendant heads 27–50 ft within the well casings.

5. Approximately 10–15 per cent of the total water injected will move seaward from the injection line.

6. A mass of saline water was pushed inland due to recharging at the test site, with the injected fresh water tending to override the saline wedge. The rate of advance of the saline water was approximately 2,200 ft in an 18-month period.

7. Ground water extractions inland from the line of injection wells apparently had little immediate effect on injection operations, although inland extractions and aquifer transmissibility determined the pre-recharge landward hydraulic gradient, which in turn determined the required injection rate per unit reach of recharge line.

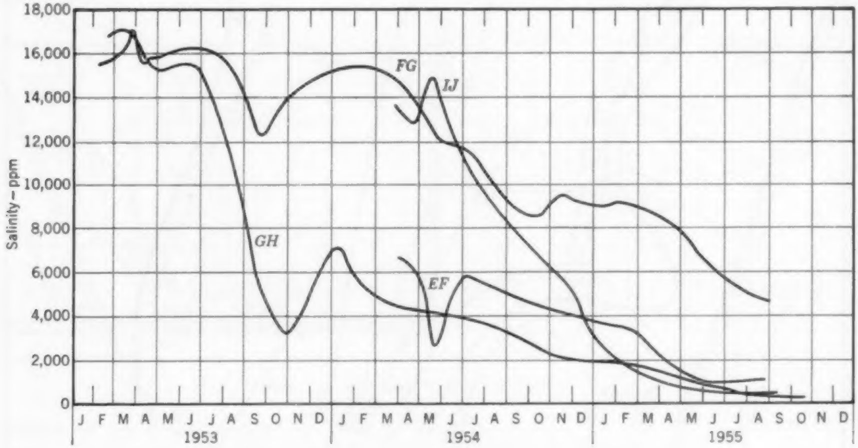


Fig. 8. Internodal Wells of Recharge Line

8. Utilizing treated Colorado River water, a 5–10-ppm chlorination rate was required at the test site to maintain desirable well acceptance rates.

Studies at Berkeley

A basic portion of the investigational program of the State Water Resources Board was the laboratory and model studies of the University of California at Berkeley. The university undertook to determine, by means of scale models, basic perimeters of sea water intrusion so as to complete the large-scale field experiment at Manhattan Beach.

The university built a small-scale model with transparent sides so that movement of fresh and salt water could be observed (Fig. 10). The center section was packed with fine sand and fitted with end chambers through which either fresh or salt water could be introduced at will. The one end represented the outcrop of the aquifer on the ocean floor and was kept full of salt water at a constant pressure; the other end was connected to a source of fresh water. By changing pressure, either a seaward flow or an overdraft condition could be simulated. Water could also be introduced through injection wells. Salt and fresh water were distinguished by the addition of fluorescent dyes, which could be vividly seen when illuminated by ultraviolet light.

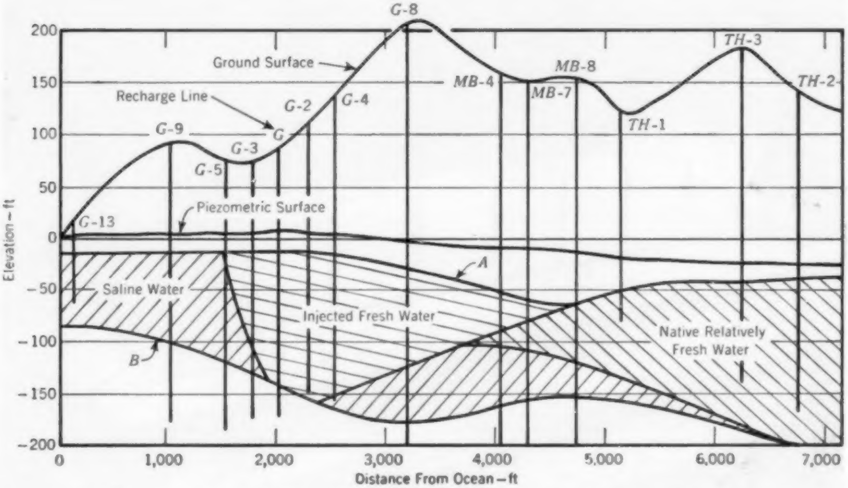


Fig. 9. Injected Fresh-Water Wedge Normal to Recharge Line

A—*upper boundary of aquifer;* B—*approximate lower boundary of aquifer. This idealized section shows the interfaces between native waters intruding sea water and injected fresh water 2 years after recharge was begun.*

Progressive encroachment of sea water into a ground water basin during a period of overdraft is shown in Fig. 10. At the time the wedge had almost passed the left injection well, fresh water was injected to satisfy the

overdraft and to supply a seaward flow which would stabilize the wedge. In Fig. 11, the aquifer section represented is 100 ft thick and 8,000 ft long, and is an idealization of the aquifer in the West Coast Basin of Los Angeles County. With overdraft and injection rates corresponding to those experienced before and during the course of the field experimental project, the prototype-time elapsed is about 10 years between the first and last photographs. The present situation at the West Coast Basin Experimental Project corresponds to Sec. D and E of Fig. 11. In Sec. E and F, partially penetrating wells might recover some of the fresh water overlying such a cutoff body of water; however, unless withdrawal rate is very small, coning develops, and salt water rises into the well due to the localized reduction in pressure.

Conclusions

The principal conclusions drawn from the experimental data obtained in the model studies of sea water intrusion were:

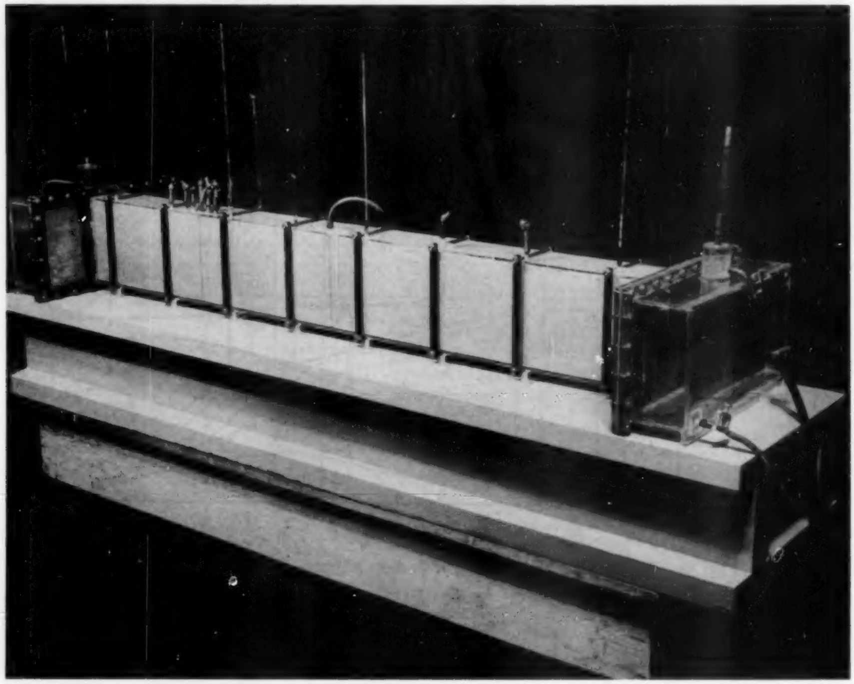


Fig. 10. Model Simulating Intrusion of Sea Water

1. In order to prevent sea water from entering an aquifer which has direct access to the sea, the fresh water piezometric surface must be held above sea level, at a distance equal to $(S-1)$, times the distance below sea level to the lowest pumping zone to be

protected, where S is the specific gravity of the ocean or inland bay water.

2. In aquifers of uniform thickness, maintaining fresh-water surface above sea level will cause a seaward fresh-water leakage in the upper portions of the aquifer. A sea water wedge will form in the lower portion, extending inland from the ocean outlet at a distance inversely proportional to the fresh water flow rate. In uniform and nonuniform aquifers, this seaward leakage may be determined from formulas given in the university's report (*2*).

3. The relationship between the equilibrium wedge length and the seaward flow rate of fresh water is independent of the distance of the aquifer below sea level.

4. There is no marked change in the shape of the fresh water–sea water interface at the beginning of an overdraft period. From any initial position, the interface moves inland at a rate determined by the rates of fresh and salt water movement. In a uniform aquifer, the wedge tends to flatten out and the toe tends to move somewhat faster than the interface as a whole as a result of greater density of salt water. In most prototype aquifers, however, the chances of nonuniformity within the aquifer make it impossible to generalize on the rate of intrusion, as the sea water may enter the more permeable portions and travel relatively rapidly within them.

5. If sufficient fresh water can be injected into the aquifer, the piezometric surface can be maintained at the required height above sea level in a region along the coast. The spacing of the wells is of little importance, except that the toe of the intruded wedge should be held at least half a well spacing seaward from the centerline of the wells. The seaward fresh-water leakage will be related to the length of the sea water wedge in the same way as before. Unless the inland demand for fresh water is reduced, however, the injection rate must equal, not only the leakage rate, but also the entire over-

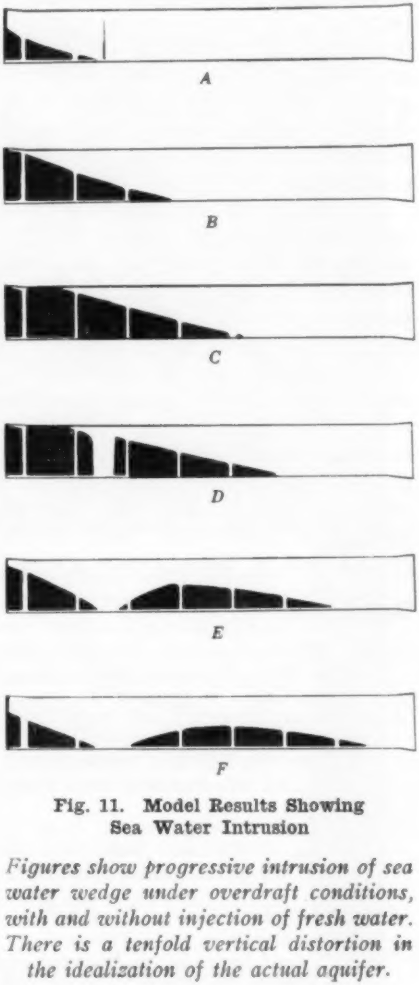


Fig. 11. Model Results Showing Sea Water Intrusion

Figures show progressive intrusion of sea water wedge under overdraft conditions, with and without injection of fresh water. There is a tenfold vertical distortion in the idealization of the actual aquifer.

draft rate which has originally caused the intrusion.

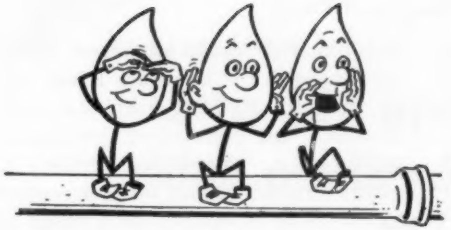
6. If fresh water is injected on top of the wedge at a rate sufficient to halt intrusion, the portion of the wedge extending inland from the wells will be cut off. It continues to move inland depending on the existing hydraulic gradient, but rate of travel will be no greater, and usually somewhat less, than the rate of travel of the entire wedge under the same overdraft conditions.

7. Unless there is a pronounced impediment to vertical flow within the aquifer, the injection of water near the bottom of the aquifer provides no benefits in the form of a reduced leakage rate.

8. Intruding sea water can be intercepted by a line of pumping wells, which will form a "pumping trough" near the coast. There will be no recharge benefits from this plan, but under proper operation, the seaward leakage of fresh water need be no greater than in the injection process.

References

1. Sea Water Intrusion in California. State Water Resources Board, Sacramento, Calif. *In preparation.*
2. Report on Laboratory and Model Studies on Sea Water Intrusion. Tech. Bul. No. 11, San. Eng. Research Lab., Univ. of Calif., Berkeley, Calif. (May 1955).
3. West Coast Basin Reference. Draft of Report of Referee. State Dept. of Public Wks., Sacramento, Calif. (Feb. 1952).
4. Sea-Water Intrusion Into Ground Water Basins Bordering the California Coast and Inland Bays. Water Pollution Investigation Report No. 1. State Dept. of Public Wks., Sacramento, Calif. (Dec. 1950).
5. Proposed Investigational Work for Control and Prevention of Sea Water Intrusion Into Ground Water Basins. Div. of Water Resources, State Dept. of Public Wks. (Aug. 1951).
6. Report to the California State Water Resources Board on Investigational Work for Prevention and Control of Sea Water Intrusion. Los Angeles County Flood Control District, Los Angeles, Calif. (Jan. 1955), *unpublished.*
7. An Abstract of Literature Pertaining to Sea Water Intrusion and Its Control Tech. Bul. No. 10, San. Eng. Research Lab., Univ. of Calif., Berkeley, Calif. (Jul. 1953).
8. An Investigation of Some Problems in Preventing Sea Water Intrusion by Creating a Fresh-Water Barrier. Report 54-94, Dept. of Eng., Univ. of Calif., Berkeley, Calif. (Oct. 1954).
9. Banks, Harvey O. & Richter, R. C. Sea Water Intrusion Into Ground Water Basins Bordering the California Coast and Inland Bays. *Trans. Am. Geophys. Un.*, **34**:575 (Aug. 1953).
10. Bauman, Paul. Experiments With Fresh-Water Barrier to Prevent Sea Water Intrusion. *Jour. AWWA*, **45**:521 (May 1953).
11. Laverty, Finley B. Recharging Wells Expected to Stem Sea Water Intrusion. *Civil Eng.*, **22**:5:25 (May 1952).
12. Laverty, Finley B. & van der Goot, Herbert A. Development of a Fresh-Water Barrier in Southern California for the Prevention of Sea Water Intrusion. *Jour. AWWA*, **47**:886 (Sep. 1955).
13. Report on Tests for Creation of Fresh-Water Barriers to Prevent Salinity Intrusion Performed in West Coastal Basin. Los Angeles County Flood Control District, Los Angeles, Calif. (Mar. 1951), *unpublished.*
14. Todd, D. K. Sea Water Intrusion in Coastal Aquifers. *Trans. Am. Geophys. Un.*, **34**:749 (Oct. 1953).



Percolation and Runoff

A happy new year, it can be for our photographic friends if they will accept the challenge of the petit picture gallery on the JOURNAL cover beginning this issue. It might have been even happier, of course—and for almost everyone—if we had yielded to the temptation of a Petty gallery instead, and substituted the cut that now appears on P&R p. 40, but, remembering that AWWA is soon to begin its 77th year, we chose confinement to the dictates of dignity and decorum and picked Vic Appleyard, Philadelphia's chief of water operations in preference to—well, instead of—Mamie Van Doren to embellish our cover.

Sizewise, it wasn't Vic's lesser photogeneity, but the necessity of retaining the list of contents, that was the determining factor. Thus, the new design is a compromise whereby we hope to add the interest of a picture cover without losing the convenience of a contented one. And those who have been wanting a picture cover are invited, urged, even commanded to unlimber their Leicas and start snapping. As a matter of fact, ours will be a happy only if theirs is a snappy new year!

The closed-circuit water system which we have described on occasion as the ultimate in self-sufficiency came a tremendous step closer to realization in mid-December, when the drought-bound city of Chanute, Kan., turned the effluent from its new $400,000 sewage treatment plant back into its water intake to add 600,000 to 800,000 gpd to its critically short supply. The recirculation involved nothing more difficult than sending the flow from the sewage plant ¾ mile back upstream to the location of the intake—a small price for such priceless stuff. And that it was really priceless was attested by the State Board of Health, whose statement that the water from the sewage plant is purer than normal river water was given prominent play in the newspaper announcement of the plan.

How downstream users along the Neosho River have reacted to Chanute's astuteness has not been reported, but, in this, obviously, they, too, can have recourse. To each, in other words, his own!

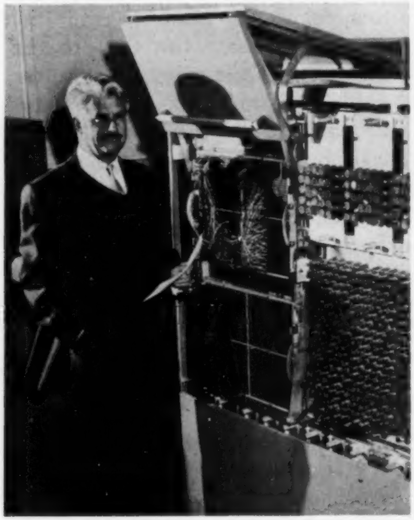
The world isn't with us any more—somehow it seems to have pushed way out in front and we find ourself almost completely at sea without a robot. Not that even a robot would help us much in plying through the intricacies of the atom or the maze of

(*Continued on page 36 P&R*)

(*Continued from page 35 P&R*)

meteorology, but, at least, like Dr. Krick below, we'd have something to keep us amused.

Dr. Krick, of course—Dr. Irving P. Krick, that is, of Irving P. Krick Associates, Inc., weather engineers of Denver, Colo., and of Water Resources Development Corp., cloud seeders of Denver, Colo.—finds his mechanical mathematician much more than amusing. With it he has been able to extend the range of his weather predic-



tions significantly and with it he expects to do much, much more probing into the long-range causes of weather. Meanwhile, on the basis of an almost perfect forecast of September 1956 temperatures made early in June, he has made firm supporters of the subscribers to his forecast service.

Elsewhere on the weather front, too, computing machines of various kinds and capacities have been helping to coordinate data on a scale hitherto unapproachable, thus to make possible such practical results as a flood warning service in the Delaware River valley, scene of the 1955 hurricane flood disaster. And even before the computation stage, tremendous strides in weather prediction and weather control appear to be in prospect as a result of current nuclear research and the findings of the International Geophysical Year, which, from Jul. 1, 1957, through Dec. 31, 1958, will combine the efforts of the world in obtaining meteorological and related information from all possible sources, including such a novel tool as the first manmade earth-circling satellite, soon to be loaded with instruments and shot out into space.

When Dr. Krick tells us about his techniques of using the Univac to project forecasts backward as a means of checking his method against actual records, we get at least a glimmer of what electronics have made possible if not how they have done so. And when Dr. John von Neumann of the AEC says:

> Our knowledge . . . is rapidly approaching a level that will make possible in a few decades intervention in atmospheric and climatic matters. . . . Measures taken in the Arctic may control the weather in temperate regions, or measures in one temperate zone may critically affect another, one quarter of the way around the globe.

we are impressed and expectant, if not exactly enlightened. On the other hand, when equally respected scientists can seriously suggest such opposite possibilities as a new ice age (based on new findings of "atomic timekeeping") and a melting of our ice caps that will flood our coastal areas (based on the increase of carbon

(*Continued on page 38 P&R*)

(*Continued from page 36 P&R*)

dioxide in our atmosphere), we are tempted to retreat to our daily weather forecasts and their more modest antitheses.

If it were just the weather that was getting beyond us, we wouldn't be too concerned, for what, after all, would we have lost? But the fact is that the current surge of robotosity has already invaded the water works field, as witness this month's JOURNAL cover. Of course, the McIlroy network analyzer isn't in a class with some of the more than just mathematical machines of the present—the new "sorter-readers," for instance, that are to be produced jointly by the National Cash Register Co. and Pitney-Bowes, Inc., to "read," electronically, "data printed or coded on checks and other original business forms, not only for the purpose of feeding the information into accounting machines, but also in order to sort the original material as may be desired"; or the Technicon Co. "Autoanalyzer," a new automatic instrument which will perform an involved series of chemical manipulations, including pipetting, dialysis, addition of reagents, heating to develop a color reaction, and recording analytical results; or the electronic librarian-reader-translators developed by such firms as Intelligent Machines Research Corp. and Documentation, Inc., to increase our "communications channel capacity" and, thereby, our capabilities. But these high-I.Q. robots can undoubtedly adapt themselves to water works subjects as easily as not, and we're just the least bit concerned that before the field itself mechanizes us out of readers, P&R will be robot-written and we'll be reduced to replacing fuses. On the chance that it works out that way, we have already put in our bid for a pun key and a confusiometer on our replacement. Meanwhile, we have a feeling that we ought to make the most of *our* understanding of the weather by a judicious combination of golf and television. Which is to suggest, if not to say: *Happy New Era!*

WSWMA's new president is Harry E. Schlenz (below), president of Pacific Flush Tank Co., Chicago. He succeeds J. A. Frank, vice-president

of National Water Main Cleaning Co., New York. Serving as vice-president of the manufacturers' association is Richard Ford, vice-president of Ford Meter Box Co., Wabash, Ind.

ASEIB—American Sanitary Engineering Intersociety Board—has elected Thomas R. Camp, of Camp, Dresser & McKee, Boston, as its new chairman; Ray E. Lawrence, Black & Veatch, Kansas City, Mo., as vice-chairman; R. S. Rankin, Dorr-Oliver Co., Stamford, Conn., as treasurer; and Francis B. Elder, APHA, New York, as secretary. Approximately 150 applicants have been approved under the board's certification program (see p. 40 P&R, September 1956 issue). Awarded Certificate No. 1 was Prof. Earnest Boyce, University of Michigan, ASEIB's outgoing chairman.

Carl A. Eberling has retired as superintendent of the Cincinnati, Ohio, water works.

(*Continued on page 40 P&R*)

(Continued from page 38 P&R)

'An amazing 34' is the way Swimquip, Inc., of El Monte, Calif., starts its description of the equipment illustrated in the photo above—"an amazing 34 sq ft of swimming pool water filtration area," that is, "is contained in the 20-in. diameter tank" to the right of—of the photo. Potency of this filly—filter, that is—is purportedly equal to three sand filters 48 in. in diameter. A dial selector valve just to the right—well, just right—is used to control backwash (hmmmm) and filter cycle. Diatomaceous earth is introduced through the slurry feeder at the left. This Swimquipment is called the Centri-Mite BF Series Filter. And BF's daughter (to the left of the filter and right of the slurry feeder, in the direction that the pointers indicate) is Mamie Van Doren, Universal-International screen star in swimquipment by Cole of California. (Employment opportunities in filtration will be carried in the new employment advertisement section—see P&R p. 42.)

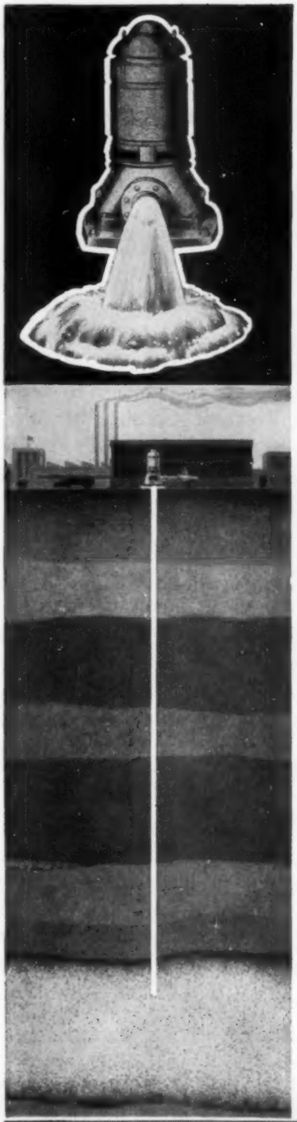
The BDSA (Business & Defense Services Administration) unit of the National Defense Executive Reserve has designated a number of additional members, including Gerald E. Arnold, general superintendent, Philadelphia Water Dept.; James C. Crenshaw, American Water Works Service Co., Islington, Mass.; Harvey S. Howe, vice-president, Lock Joint Pipe Co., East Orange, N.J.; and Thomas T. Quigley, assistant to the president, Wallace & Tiernan Inc., Belleville, N.J. Industry representatives selected for the reserve agree to accept certain responsibilities in the federal government in the event of an emergency and to perform limited service in peacetime. Meanwhile they are not government employees and are subject to no requirements other than those necessitated by short periods of training.

Emil C. Jensen, chief of the Div. of Engineering of the Washington State Dept. of Health, has been elected president of FSIWA for 1956–57. The new vice-president is Kenneth S. Watson, consultant on water management and waste control, General Electric Co., Schenectady, N.Y.

W. Harry Smith has joined the staff of Cast Iron Pipe Research Assn., after 8 years with the Illinois Dept. of Health and the Illinois Sanitary Water Board. As regional engineer (since 1951) he was responsible for all the sanitary engineering field work in his area.

Allis-Chalmers Mfg. Co. has opened a branch office at 508 Turner St., Allentown, Pa., under the management of Ralph L. Haney, a sales representative in the firm's Boston district since 1946.

(Continued on page 42 P&R)



(*Continued from page 40 P&R*)

Employment Information

Because of a recent large increase in the volume of requests for the publication of employment information, the JOURNAL has decided to change its policy and, on a trial basis, to accept classified advertising under this heading, beginning with the March 1957 issue. Categories will be limited to "Positions Available" and "Positions Wanted."

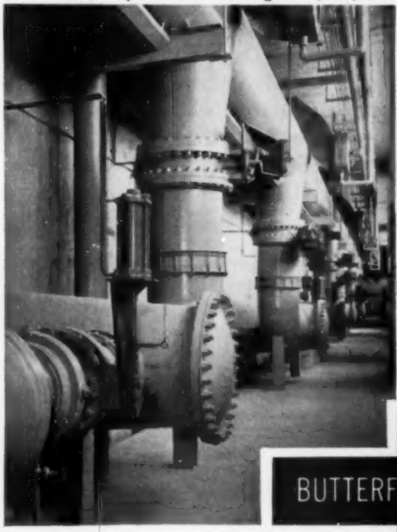
Advertisements will be printed in 6-point type, and will be charged at the rate of $1.50 per line (minimum charge, $5.00), *payable in advance*. (In calculating charges, assume six words per line, count *each* element of a compound word or proper name as one word, count each word to be printed all in CAPITALS as two words.)

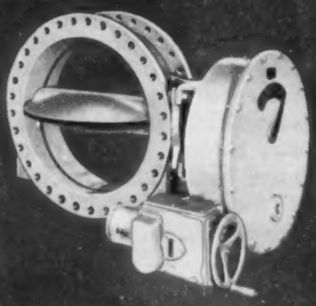
Copy must be received no later than the first of the month prior to that in which the ad is intended to appear (i.e., for March, the deadline is Feb. 1). Copy and payment should be sent to: Classified Ad Dept., Journal AWWA, 2 Park Avenue, New York 16, N.Y.

Augusta, Ga., has announced an opening for a water works superintendent. Preference will be given to graduates of accredited engineering schools. Five years' experience as a water works superintendent or assistant is required. Apply to: Director of Personnel, City Hall, Augusta, Ga.

(*Continued on page 44 P&R*)

DROP-TIGHT SHUTOFF R-S Rubber-Seated Butterfly Valves give drop-tight closure to 125 psig through wedge-type action of the disc within a one-piece rubber seat. 65 of these valves, installed as shown for service in the San Jacinto River project near Houston, gave a substantial space reduction and direct, in-place cash savings of $124,000.





FOR HIGH-PRESSURE SERVICE SMS Babbit-Seated Butterfly Valves are built to give tight shutoff and meet the rugged demands of high-pressure service. They are available for shutoff pressures up to 200 psig, and for a wide range of velocities, including open-end free discharge.

BUTTERFLY VALVES

GET POSITIVE SHUTOFF, CUT CONSTRUCTION COSTS

For high or low-pressure water service, SMS has the Butterfly Valve to give you tight shutoff and help reduce construction costs. Using SMS or R-S Butterfly Valves in place of conventional gate valves permits a much more compact piping layout, means substantial savings in the initial building costs. For full information on the complete SMS valve line – Butterfly Valves, Ball Valves and Rotovalves – see our local representative or write S. Morgan Smith Co., York, Pa.

HYDRAULIC TURBINES · GATES & HOISTS · TRASH RAKES · PUMPS · ACCESSORIES

HYDRODYNAMICS

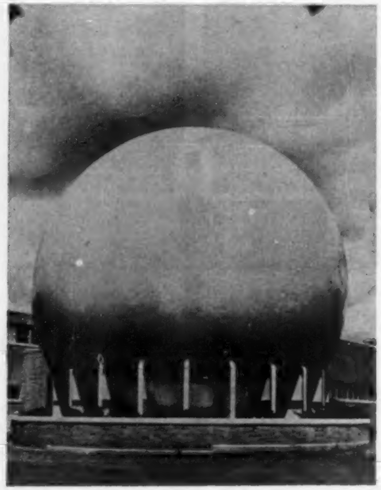
ROTOVALVES · FREE-DISCHARGE VALVES · BALL VALVES · CONTROLLABLE-PITCH SHIP PROPELLERS · BUTTERFLY VALVES

SMS S. MORGAN SMITH

AFFILIATE: S. MORGAN SMITH, CANADA, LIMITED • TORONTO

(*Continued from page 42 P&R*)

Tanks are being welcomed these days rather than just tolerated, and the secret of the change has been the discovery that their conspicuousness can be put to advantage. Thus, in industry, the water tank—elevated or otherwise—is more and more being featured rather than hidden. General Motors, for instance, had the tank at its new technical center in Detroit made of stainless steel and then incorporated the form of the 250,000-gal structure (left photo) in the technical center insignia. S. C. Johnson & Son, waxmakers, set their 200,000-gal spherical tank (center photo) on the ground right at the entrance to their Sturtevant, Wis., shipping center and then used its form as a sort of ball-of-wax trademark on their printed matter. Gerber Products Inc. has been even more direct, in having its tanks made in the shape of baby-food jars and then labeling them in paint. And the 40,000-gal golf ball on a 65-ft tee (right photo) at the Tam O'Shanter Country Club in Chicago is almost as famous as the size of the club's tournament prizes. Meanwhile, even old tanks seem to be getting into the act to attract, with Putnam Publishing Co. in Chicago giving the old-fashioned wood tank atop its building a new personality in a paint job that produced a pretty face and a demure look, although no sales significance. Down in Caracas even homebuilders have followed the lead, the $100,000 home of the Jose Santi Romero family sporting a 550-gal sphere atop its roof terrace. Not only does the sphere add interest to the structure, but information as well, for on it is painted a large-scale map of the world.



Next in line, of course, are our municipal water tanks, which to date have pretty much limited their decorations to the names of the communities they serve. We remember that some midwestern community went so far as to mount its television aerial atop its tank and we have just learned of the Christ-

(*Continued on page 46 P&R*)

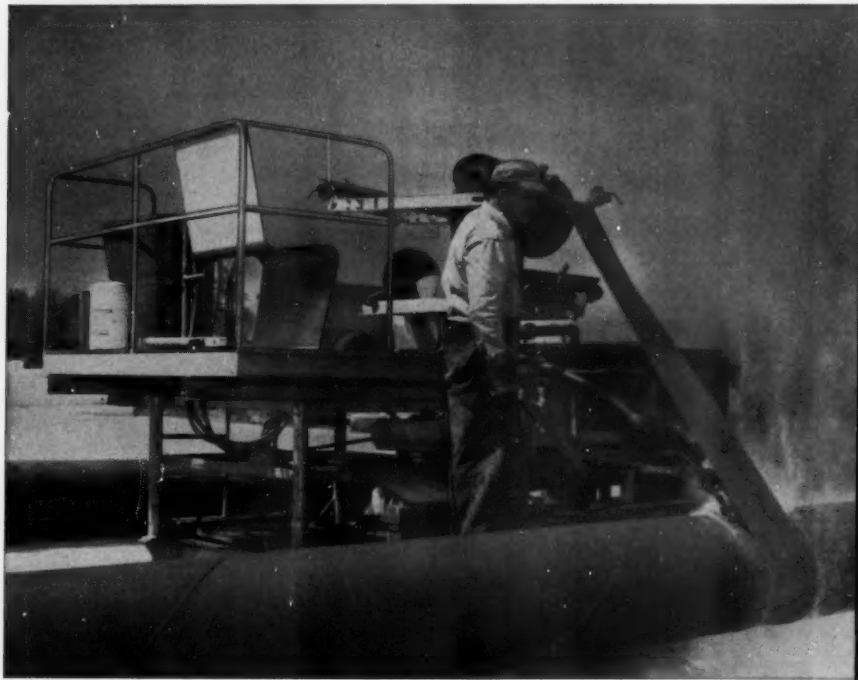
(*Continued from page 44 P&R*)

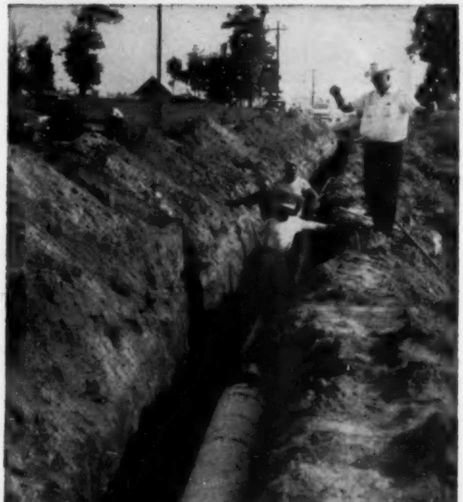
mas-decorated sphere at New Smyrna Beach, Fla., but, on the whole, water utilities have been inclined to keep these servants of the public as silent as possible. In so doing they may have reduced in some small measure the unhappiness of residents of the immediate vicinity, but just consider the lost opportunities—the beer-bottle standpipes of Milwaukee, Wis., the elevated Brownies at Rochester, N.Y., the high hats at Danbury, Conn., the sky-scraping oranges at Lemon Grove, Calif., the lofty tulips of Holland, Mich., and at the nation's capital, to avoid the necessity of changing pianos to golf balls, perhaps just eminent domes. Not really convinced that many water customers will be any more anxious to have, for instance, titanic tomatoes than plain elevated tanks in their backyards, we have an idea that it will continue to be industry that keeps water tank design from getting into a rut. And if the Chicago Bridge & Iron Co., which designed and built the slightly unconventional tanks pictured and discussed here, isn't prepared to give the Kayser hosiery company the kind of standpipe that it really owes its audience, we are certain someone will. And in addition to advertising an industry's products, such tanks for the memories can't help but remind the public of industry's dependence upon water. For which, of course, we will owe tanks thanks.

Black & Veatch, consulting engineers, Kansas City, Mo., have moved from 4706 Broadway to new quarters at 1500 Meadow Lake Pkwy.

(*Continued on page 50 P&R*)

LENOIR, N. C. PLANS FOR THE FUTURE WI





Special machines designed by Koppers Contract Coating Departmen were used to prepare pipe fo Lenoir's new 10-mile water line 50-foot lengths of spiral-welded pipe were sandblasted, given an interna and external sprayed coat of Bitumastic 70-B AWWA Primer and ther brought to the lining, coating anc wrapping machines. There, the pipe was lined, then coated with Bitumastic 70-B AWWA Enamel. A tar saturated asbestos felt wrap was simultaneously applied over the enamel coating. After testing electrically and whitewashing, the pipe was ready for shipment to the ditch

Ter
bei
BIT
for
anc

Face
lation
wate
steps
futur
line
bring
the C
furnit
Blue
lion
line
the fi

Cit
engin
and S
steel
with
amel
At a
its co
Coati
prime

(Continued from page 46 P&R)

Orsanco—Ohio River Valley Water Sanitation Commission—reports gratifying progress in its drive for clean streams within the eight-state area it covers. Purification facilities now serve 75 per cent of the sewered population of the valley, compared with less than 40 per cent in 1948, when the commission was organized. Of the 1,438 industrial plants discharging wastes into streams of the valley, 965 are complying with minimum requirements adopted by the commission. Although these figures are encouraging, the commission will continue to devote major attention to industrial-waste control. Current commission activities include comprehensive water use impairment studies, river quality monitoring, and—in conjunction with the USPHS Taft Sanitary Engineering Center—investigations on quality changes that may be associated with atomic-energy developments.

Kenneth M. Lloyd, secretary, Mahoning Valley Industrial Council, Youngstown, Ohio, has been installed as the new chairman of the Ohio River Valley Water Sanitation Commission. Appointed vice-chairman is B. A. Poole, director, Bureau of Environmental Sanitation, State Board of Health, Indianapolis, Ind.

Garvin H. Dyer, director of Missouri Water Co. and manager and chief engineer of its Independence Div., has been nominated for president of the National Society of Professional Engineers. A former NSPE national director, he is currently serving his second term as vice-president of the society's North Central Region. Mr. Dyer was chairman of the Missouri Section of AWWA in 1951–52.

The hose dives abcut which we have been hearing for the past 2 years or more seem to continue unabated. In November (P&R p. 42) it was at Parris Island, S.C., that a garden hose self-interment defied both the efforts and understanding of the Marine Corps. And now a similar indignity in New Market, N.J., has made the front page of the Newark *News*, with a picture of a 5-ft excavation that apparently has uncovered only half the missing length. At last, however, we have some explanation of the phenomenon in a story from West Glacier, Mont., where a big black bear was reported to have eaten 3 ft of plastic hose, presumably mistaking it for a snake. We'd get under cover, too!

Curtiss M. Everts Jr., on leave from duties as chief sanitary engineer of the Oregon Board of Health, has been named to direct the initial operation of the construction grants program authorized by the recently enacted Federal Water Pollution Control Act.

Ezra B. Whitman has retired from active partnership in the consulting firm of Whitman, Requardt & Assocs., Baltimore. Mr. Whitman entered private practice in 1915, after serving as president of the water board and water engineer for the city of Baltimore.

Kenneth Brunner has moved his engineering office to 8339 E. 2nd St., Downey, Calif. He was formerly located in Los Angeles.

Harvey C. Waugh, formerly vice-president of American Water Softener Co., has joined Roberts Filter Mfg. Co., Darby, Pa.

(Continued on page 52 P&R)

(*Continued from page 50 P&R*)

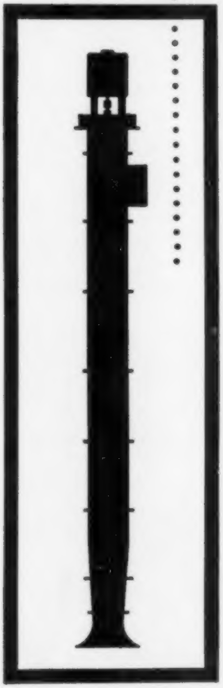
Forty-niners are back in California again, but this time it's a state, not a date, that gives them their name. As for their purpose—a forty-ninth state—it's WATER, of course, that gives them that. It's water that they have, too, for the forty-niners are those residents of Northern California who feel that the grandiose California Water Plan is going to bleed the north to build up the south. A new state—tentatively named Shasta—will, they feel, put them in a position to protect their rights and to make the south pay for any transfusions obtained.

Although next month's issue, which will give the full story of the Plan, will probably precipitate the JOURNAL into the midst of the numbers racket, for the moment we can neutralize by agreeing that the issue is certainly worth the strong feeling. We do recommend, however, that if such a split is made, the dismembers be named Calif and Ornia, thus to help preserve our strong feeling for both ends of the present sovereignty.

William E. Sees Jr., consulting engineer, formerly located in the State Chamber of Commerce Bldg., Harrisburg, Pa., has moved his offices to 4335 N. Front St. in that city.

William B. Schworm, senior chemical engineer, St. Louis Water Div., Howard Bend Sta., Chesterfield, Mo., received the Fuller Award in 1955, a fact that was duly noted in the December 1955 JOURNAL but was regrettably omitted from his listing in the 1956 *Directory*.

(*Continued on page 88 P&R*)



Correspondence

Rhabdomantic Research Requested

To the Editor:

Once again the dowsers are loose in the land (August P&R, p. 36). From Roberts & Co. to Joe Doaks, the populace is aroused. Trees from Maine to California are being denuded of their branches that they may bow in supplication before the shrine of the God of Waters. Friendships of long standing are torn asunder. One looks in despair at the unfortunate who has so completely forgotten the principles of logic and the teachings of his alma mater. The ultra-conservative water supply profession is being invaded by a radical element to the distress of the faithful and the confusion of the craft.

Those who have experienced the twigs' strange reactions are accused by the intellectuals of being the victims of a subconscious mind disturbed by earlier indiscretions, while the man in the street accuses them of having holes in their heads or worse, or of being fakers or liars. Are they?

Go back in time only a little over a generation and tell a group of educated people of the period that you sat in your home watching and listening to a speaker in a distant city, and heard his words the instant he spoke them. Imagine the reception you would get!

Only a short time ago the scientist considered atoms to be indivisible, yet today we take them apart and rebuild them—sometimes with terrifying results. All this adds up to the fact that there are many things we do not know or understand at present, for which we should, perhaps, be thankful.

Why do we ridicule what we do not understand? Forget the dowser's willow for a moment and consider the brass rod pipe locators mentioned several times in P&R. With no nearby objects to serve as an explanation for their movement, why do the rods turn in the hands of the operator until they parallel a line of buried pipe? The question is simple, the answer . . .?

Let us stop these senseless arguments on something none of us *knows* about and start some sound research, backed by sufficient funds, to obtain an answer.

R. G. YAXLEY

Waterford, N.Y.
Oct. 4, 1956

Professional Services

Professional Services

Condensation

Key: In the reference to the publication in which the abstracted article appears, **39**:473 (May '47) indicates volume 39, page 473, issue dated May 1947. If the publication is paged by the issue, **39**:5:1 (May '47) indicates volume 39, number 5, page 1, issue dated May 1947. Abbreviations following an abstract indicate that it was taken, by permission, from one of the following periodicals: *BH—Bulletin of Hygiene (Great Britain); CA—Chemical Abstracts; Corr.—Corrosion; IM—Institute of Metals (Great Britain); PHEA—Public Health Engineering Abstracts; SIW—Sewage and Industrial Wastes; WPA—Water Pollution Abstracts (Great Britain).*

HEALTH AND HYGIENE

Ten Years of Fluoridation. J. R. Forest. Monthly Bul. Ministry Pub. Health & Pub. Health Lab. Svce., **15**:79 ('56). Not too technical summary of Newburgh, N.Y., fluoridation study report, published March '56. Includes discussion of findings concerning effect of fluoridation on deciduous and permanent teeth, enamel mottling, general health of children, still-birth and infant death rates, cancer, cardiovascular and renal disease rates. Article concludes that artificial fluoridation at 1–1.2 ppm is as beneficial as naturally occurring fluoridation, and in no way detrimental to health.—*PHEA*

The Brantford-Sarnia-Stratford Fluoridation Caries Study 1955 Report. H. K. Brown, et al. Can. J. Public Health, **47**: 149 ('56). Brantford has had more than 10 yr of experience with 1 ppm fluoride in its water supply. During that time a very important, statistically significant reduction in tooth decay occurred in all the age groups studied, while in the 2 control cities of Sarnia and Stratford it has either remained at about the same level or increased somewhat. Children born in Brantford since fluoridation began now exhibit same degree of resistance to dental caries as those of corresponding age group in Stratford, where water containing about 60% more fluoride than Brantford water, has been consumed during the past 38 yr. No ill effects of either medical or dental nature have been revealed by study, or reported by medical profession, dental profession, or by health authorities in either Brantford or Stratford. These findings and corroborating evidence from other contemporary studies have provided basis for recent official recommendations by Canadian Dental Association, Canadian Medical Association, and Canadian Public Health Association that fluoride concentration of all fluoride-deficient water supplies be raised to 1 ppm by mechanical addition of fluoride. A fact of fundamental importance in public health has been established. Raising fluoride content of fluoride-deficient water supply to about 1 ppm will lower attack rate of tooth decay among children born subsequent to fluoridation, to about ⅓ of that which prevails among those born and continuing to reside in communities which have no fluoride in their water supply, such as Sarnia. For every 3 decayed teeth they would have had, they have only 1. —*PHEA*

The Conclusion of a Ten-Year Study of Water Fluoridation. D. B. Ast & E. R. Schlesinger. Am. J. Public Health, **46**: 265:71 ('56). This 10 yr. study was carried out in 2 cities about 35 mi. apart on the west bank of the Hudson R. Newburgh, N.Y., served as test city and water was fluoridated to fluoride content of 1.0–1.2 ppm. Kingston, N.Y., served as control city and continued to use natural, untreated water with fluoride content of approximately 0.1 ppm F. Base line data showed the 2 communities to be similar in dental caries experience. At conclusion of the 10 year study, children from Newburgh, at age levels of 6–9 yr, 10–12 yr, 13–14 yr and 16 yr, showed 58%, 53%, 48%, and 41% fewer decayed, missing or filled teeth respectively than children from corresponding groups in control city of Kingston. Other observations were made which showed the proximal surfaces of teeth to be selectively protected as compared with occlusal surfaces in groups receiving fluoridated water. No disfigurement or noticeable dental fluorosis was noted in treated water groups. Fewer nonfluoride opacities were noted and slightly less gingivitis was found in treated-water groups. Exhaustive studies were carried out during final year of study to determine effect on systemic development of long-term ingestion

(*Continued on page 64 P&R*)

(*Continued from page 62 P&R*)

of fluoridated drinking water. No significant differences could be demonstrated between treated water and control groups. At fluoridation level of 1.0–1.2 ppm dental caries were effectively reduced and no danger of fluorosis could be demonstrated.—*PHEA*

Fluoridation of Water Supply. The Norway, Maine, Study. A. W. GARCELON. New England J. Med., **254**:1072 ('56). Report of 30-mo. study in Norway, Me., to determine whether or not beneficial effects of fluoridation become apparent in less than 5 yr. Results of study compared to 6 other short-term studies in other parts of US. All studies cited showed considerable reductions in number of DMF permanent teeth per child, attributable to fluoridation. Theory that fluoridated water washing over erupted permanent teeth has some beneficial effect is also supported. Beneficial effects of fluoridation become apparent within 30 months.—*PHEA*

Fluoridation of Public Water Supplies in Massachusetts. Sanitalk, **3**:10 ('55). Fluoridation of water supplies in Massachusetts has been under study since 1946 and is now being practiced in 17 communities. Usual method of fluoridation is by dry-feeding sodium fluoride, although in small communities with water consumption of less than 1 mgd soln.-feeding of sodium fluoride has proved satisfactory. Daily checks are made on concn. of fluorine in fluoridated water supplies, and in spite of minor operational difficulties, concn. rarely varies 0.9–1.1 ppm fluorine. Fluoridation of all public water supplies in Massachusetts is recommended, since natural fluorine concn. avgs. only 0.1 ppm, although in rare instances 2.0 ppm has been reported for well water.—*WPA*

Fluoridation of Town Water Supply. F. J. GREY. Commonw. Engr. (Br.), **43**:91 ('55). Since 1953, fluorides have been added to water supply of Beaconsfield, Tasmania. At 1 of 2 treatment plants, surface water

(*Continued on page 66 P&R*)


"THERE IS
CONCRETE PRESSURE PIPE
IN MAJOR CITIES
OF EVERY STATE"

(*Continued from page 64 P&R*)

is impounded in reservoir with capac. of 30 mil gal. Water is soft, with avg. carbonate hardness of 16 ppm and is colored. During dry weather, surface-water supply is augmented with spring water which is colorless and has hardness of 280 ppm. It is softened with lime to hardness of 70 ppm before mixing with surface water in reservoir. Water is then coagulated with alum and activated silica in an upward-flow sludge-blanket unit. Second treatment plant was designed as pilot plant to study treatment of water from South Esk R., which has hardness of 30 ppm and color of 70 ppm and is of varying turbidity. Sodium silicofluoride is added to both supplies to give concn. of 0.8–1.0 ppm fluorine.—*WPA*

Further Studies on Methemoglobinemia in Children Due to Nitrates. Investigation in the Province of Trapani. M. Cefalu & G. D'Ambrosio. Nuovi Ann. Igiene Microbial. (Italy), **5**:404 ('54). It has been stated that infant cyanosis may be caused by nitrates secreted in human or cow's milk in areas where excessive amt. of these compds. is present in water supply. This is refuted by anal. of milk of 42 mothers and 58 cows in 2 rural districts in Sicily where water supplies contained generally more than 50 and sometimes up to 800 ppm nitrate ion. In no case was nitrate discovered by test sufficiently delicate to show presence of 10 ppm. Careful inquiries made of health of 92 infants (mostly under 12 mo.) with view to discover incidence of cyanosis which might be due to nitrates; 27 had been breast fed only, but probably had also been given small quants. of plain water; 65 had been partly breast fed and partly artificially fed; and 14 artificially fed from birth. Many, especially in latter categories, had suffered from attacks of gastroenteritis and some were suffering in this way at time of inquiry which was made of parents by local doctor and health assistant. Only 3 had possible history of cyanosis: [1] infant had had severe attack of gastroenteritis, at 6 mo., when it had a brief cyanotic crisis; 1 mo. later when investigation was made, infant still had diarrhea but no cyanosis; [2] infant of 10 mo. had had during eighth mo. acute gastroenteritis with intensive cyanosis, which led parents to call for medical aid; and [3] infant of 3 yr had slowly increasing cyanotic tint. There was no history of illness and clinical examn. was negative. All 3 babies had been artifically fed with milk reconstituted with aid of water with very high nitrate content. Authors remark that cyanosis is due to methemoglobinemia caused by nitrates in drinking water, and that it is real danger in circumstances prevailing in locality.—*BH*

Bacteriological Aspects of Dairy Water Supplies. W. A. Cuthbert. J. Soc. Dairy Technol., **8**:181 ('55). It has been shown that contaminated water supplies may endanger health of consumers or may lead to defects in milk which will threaten its useful life. Water consistently free from coli-aerogenes in 100-ml quantities may safely be regarded as being free from disease-producing organisms, but may still be capable of producing defects. Where this is suspected, supply should be so treated that at time of use it shows only a low colony count at 22° and an absence of milk-souring organisms in 10-ml quantities.—*PHEA*

SOFTENING AND IRON REMOVAL

Economic and Operating Aspects of Mixed-Bed Deionizers With Hard and Soft Water Supplies. J. F. McGill. Power, **98**:79 ('54). Effect of hard water on capacity, effluent quality, and cost of ion-exchange equipment discussed. 10 methods for treating hard water in mixed-bed ion-exchange units compared.—*WPA*

Softening With Ion-Exchange Materials in Water Circulation. M. Cejka. Voda, **32**:134 ('52). Causes of loss of efficiency in softening with "Ionex" filters, whose material has sulfonated coal basis and operates in the acid cycle with regeneration with sulfuric acid, are separation of calcium sulfate, and the period of flow-through of sulfuric acid during regeneration. In all cases concentration of calcium sulfate in sulfuric acid leaving lowest layer of material must be considerably less than solubility product.—*WPA*

Removal of Iron From Water in Sedimentation Tanks in Works With Their Own Power Plant. W. Metzler. Wasserw.-Wass. Techn., **5**:34 ('55). Author describes model plant for removal of iron

(*Continued on page 68 P&R*)

(Continued from page 66 P&R)

from water, comprising sedimentation tanks and filters. Ground water to be treated has content of 10–50 mg of iron per liter and is aggressive. It is deacidified by spraying in open, and addition of lime water. Mixed condensate water at temperature of 30°–40° C is added to encourage flocculation and prevent freezing of sprays and sedimentation tank. Use of ground water for condensation is limited as far as possible. Plant and its operation are described. Iron oxide sludge is used for purification of gas. Rise in ground water level has reduced concentration of iron from 50 to 10 mg/l.—*WPA*

The Deferrization of Water by Private Industry in Saigon-Cholon, Vietnam. A. Vialard-Goudou & C. Richard. L'Eau, **42**: 215 ('55). 75% of water supply of Saigon is ground water obtained from 20–30 deep wells. While bacteriologically satisfactory, it contains 5–20 mg/l Fe_2O_3. 6 methods of removing this iron by oxidation, alkalinization and filtration are described for as many private enterprises requiring iron-free water. —*PHEA*

New Experiences in Treatment of Water With Decarbolith. Eckstein. Stadthygiene, **6**:65 ('55). After general account of use of alkaline filter materials for removal of acid, iron, and manganese from water, author deals specially with material "Decarbolith." This is prepared by calcining a dolomitic material, from deposit near Gera, to content of 1–2% magnesium carbonate. Calcining to the calcium oxide stage produces treated water with too high alkalinity. Material is prepared in different grain sizes for open or closed filters. Crude dolomite has proved satisfactory as supporting layer. Material has been used for removal of iron, manganese, and acid from cold waters; is heat resistant and can be used for water in hot-water circulation systems and for circulating boiler water.—*WPA*

The Removal of Iron From Water. M.-A. Lapaix. L'Eau (Fr.), **42**:89 ('55). Author discusses problem of iron in water, how iron gets in water, physical characteristics of ferruginous water, and inconveniences of iron in potable and industrial waters. Basic theories of iron removal, together with chemical formulae, are presented. Chemistry and engineering of iron removal are discussed, showing several types of equipment and formulas used. Bacteriology of ferruginous water, especially with regard to iron bacteria, is discussed.—*PHEA*

Application of Ion Exchangers in Inorganic Technical Processes. B. Wenke. Iva (Swed.), **26**:208 ('55). Tech. aspects of water softening and total and partial demineralization, recovery of CrO_3, and electrolytic desalting by use of ion-exchange membranes are reviewed.—*CA*

Stabilization of Lime-softened Water. A. A. Hirsch. Proc. 18th Ann. Short Course for Water and Sewerage Plant Supts. and Operators, Mar. 16–18, '55; Louisiana State Univ., Eng. Expt. Sta. Bull., No. 53: 144 ('55). Comprehensive review, based mainly on Langelier formula, discussing following methods of control: strong acids, acid salts, coagulants, H-exchange-resin effluent, CO_2, Cl, Na zeolite effluent, polyphosphates, temp., and solids content. Methods for lab. evaluation are described. 16 references.—*CA*

Joint Hydrogen-Sodium Cationization. R. L. Babkin. Elek. Stantsii (Rus.), **26**:15 ('55). Joint H-Na cationization without 2nd stage does not assure constancy and high qual. of chemically purified water. Joint H-Na cationization, with subsequent Na cationization, is quite satisfactory for use at elec. stations.—*CA*

Four Water Treatment Methods to Remove Algae, Hardness, and Dissolved Solids. D. C. Swift. Power, **100**:88 (May '56). General disc. of chlorination, softening, distn., and cation-anion exchange, citing fields in which each is most effective.—*CA*

How to Remove Iron and Managanese From Industrial Process Water. E. Nordell. Power, **100**:91 (Apr. '56). In process water Fe and Mn can be very troublesome. 5 methods, using filtration, softening, and zeolite softening, are charted and described. Typical Fe- and Mn-bearing waters are tabulated. Application of different methods to different waters is suggested. *Ibid*, 100:100 (May '56). Effect of pH and value of oxidation are stressed. Various methods can be selected and combined to give more efficient results and control corrosion sometimes stimulated in this type of treatment.—*CA*

(Continued on page 70 P&R)

(*Continued from page 68 P&R*)

WELLS AND GROUND WATER

Ground Water, River Water, Sewage and Their Relationship. G. THIEM. Gesundh. Ing. **76**:276 ('55). After description of origin and extent of ground water resources of Germany, author deals with advantages of ground water as supply and recommends its more general consideration even if supply has to be brought from distance. He then deals with production of artificial ground water, giving equations for calculation of amount obtainable and distance from river to the ground-water intake. Effects of pollution of rivers and the importance of methods of reducing pollution discussed.—*WPA*

Water Bearing Strata in Greater Brittany. R. C. S. WALTERS. Tech. Sanit. & Munic. (Fr.), **50**:179 ('55). Geological formations underlying southern England and northern France described in relation to water-bearing strata.—*PHEA*

Ground Water for the Supplemental Water Supply of Salzburg. F. SITTE. Gas, Wasser, Wärme (Ger.), **9**:171 ('55). This article gives detailed hydrogeological anal. of underground water supplies in region near City of Salzberg, Austria. Precipitation, availability of water, hardness, regional geology, present wells, and other factors considered.—*PHEA*

Geology and Ground-Water Resources of Galveston County, Texas. B. M. PETITT JR. & A. G. WINSLOW. Texas Board of Water Engrs., Bull. No. **5502** ('55). Hundreds of chem. anals. of waters are given. Salt-water encroachment is serious problem in area.—*CA*

Geology and Ground-Water Resources of Buena Vista Valley, Pershing County, Nevada. O. J. LOELTZ & D. A. PHOENIX. Nevada State Engr., Water Resources Bull.

(*Continued on page 72 P&R*)

(*Continued from page 70 P&R*)

No. **13**:1 ('55). Chem. anals. of 14 waters are given. Some are highly mineralized, but most are hard waters suitable for irrigation.—*CA*

Metamorphism of Natural Waters in the Crust of Weathering. II. I. I. CHEBOTAREV. Geochim. et Cosmochim Acta, **8**: 137 ('55). Summary of factual data is presented covering fields of hydraulics and salinity of waters, subterranean waters in oil fields, chem. compn. of natural brines, salt domes and assocd. waters, subterranean waters of volcanic assocn., salinity of water assocd. with metalliferous deposits, and salinity of waters from sedimentary, metamorphic, and igneous rocks. 68 references. —*CA*

Metamorphism of Natural Waters in the Crust of Weathering. III. I. I. CHEBOTAREV. Geochim. et Cosmochim. Acta, **8**: 198 ('55). Discussion of data from hydrological approach; cycle is formulated relating salinity, hydrochem. facies and geochemistry of chloride, sulfate, and bicarbonate waters.—*CA*

Geochemistry of Subterranean Waters. Application to the Waters From Petroleum Deposits. H. SCHOELLER. Rev. inst. franç. pétrole, **10**:181 ('55). Graphical methods of presenting water analyses and sulfate reduction, base exchange, and chemistry of ground waters are reviewed. Influence of gas and petroleum-formation reactions on properties of assocd. water is discussed.—*CA*

Quality of Ground Water in the Stockton Area, San Joaquin County. ANON. Calif. Div. Water Resources, Water Quality Invest. Rept. No. **7**:1 ('55). Complete chem. anals. of 131 samples and partial anals. of 486 samples are given. Waters to depth of 600 ft are $Ca(HCO_3)_2$ waters; below this to depths of 950–1150 ft is zone of $NaHCO_3$ waters, which are underlain by waters high in NaCl. Anals. over 20-yr period indicate little vertical migration of the chloride waters.

FOREIGN WATER SUPPLIES—GENERAL

The Water Supply of England and Wales. A. N. GARDINER. J. Brit. Wtr. Wks. Assn., **37**:363 ('55). Details are given of main water undertakings, numbering about 1500, of England and Wales, and comprising local authority undertakings, joint water boards and privately owned companies; their respective constitutions and powers are outlined. Since the war unmetered consumption per head has remained steady; for design purposes 30 to 40 gpd per head is allowed according to the area. Metered supplies for industry and piped supplies to farms have increased rapidly. Sources of water are described in detail. About 930 mgd is extracted from underground strata; principal areas are shown on a map. Measures to prevent undue exploitation or overpumping of these resources have been adopted by the Minister of Housing and Local Government under Water Act of '45. Most industrial areas in north and west derive gravity supplies from impounding reservoirs in upland regions; regulations specify amount of compensation water to be returned to rivers. Number of authorities derive supplies from rivers and pump water to areas of supply, usually from open storage reservoirs. In this connection, statistical data and other information is given regarding Metropolitan Water Board. Number of small undertakings are supplied by springs, but with a few exceptions amount of water obtainable is small and yields are too unreliable for use by large undertakings. Main treatment processes applied to water from above sources are summarized.—*WPA*

Water Supplies of Wales and Monmouthshire. A. E. GUILD. J. Brit. Wtr. Wks. Assn., **37**:389 ('55). Abundant water sources of Wales and Monmouthshire are derived mainly from upland catchment areas, average annual rainfall of which is 50 in. Other sources, used chiefly for supplying hill farms, are derived from springs and wells. Authorities distributing water are for most part municipal authorities, but there are a number of joint water boards and water companies, and the Taf Fechan Water Supply Board which supplies in bulk to municipal authorities and boards. Principal water works, their sources of supply, and treatment processes are described, including those of Cardiff, Newport and Pillgwenlly, Wrexham and East Denbighshire, and Swansea. In addition, details are given of reservoirs and dams constructed in catchment areas to supply water to Birmingham, Liverpool, and Chester in England.—*WPA*

Water Testing in the Field

*APPROVED Water Pollution Control Technique

FIELD MONITORING KITS MAY BE CARRIED INTO THE FIELD to conduct studies of water pollution far from central laboratory facilities or to collect water samples for later analysis. A Field Monitor consists of a disposable plastic dish having a sealed-in Millipore Filter (MF®); there is also a Sampling Tube and an ampul of Coliform MF® Endo medium. All are sealed, sterile and ready to use.

The Sanitarian provides himself with a Sanitarian's Kit consisting of an all-metal syringe, valve, and sample cup. These need not be sterilized.

A SAMPLE OF THE PROPER SIZE IS TAKEN in the stainless steel cup. The cup must first be thoroughly rinsed in the same water from which the sample is to be taken. (Figure 1.) The syringe valve and sampling tube are plugged into the Field Monitor (they won't assemble incorrectly). The syringe plunger is drawn back and held to pull the sample up through the Field Monitor. (Figure 2.) Large samples may require several strokes. Monitors must be held upright to draw the last few drops from the filter. (Figure 3.) The plastic sampling tube is then removed and discarded.

THE TIP OF AN AMPUL OF MEDIUM IS BROKEN and the ampul is inserted into the Monitor (Figure 4.) The top of the ampul is then broken and the ampul lifted very slightly to allow the medium to flow into the Monitor, (Figure 5.) A partial stroke of the syringe will draw the medium through the filter. (Figure 6.) It is important to STOP pulling on the syringe the INSTANT the last few drops of the medium disappear from the filter surface. The protective caps are then replaced. (Figure 7.)

THE FIELD MONITOR IS INCUBATED for 20 hours at 35°C. (Figure 8.) If desired, the Monitors may be replaced in their boxes and forwarded to a central laboratory for incubation. Special holding media may be substituted for Endo media if shipping delays over 48 hours are expected. Naturally, samples can be held for only short periods in excessively high temperatures (42°C or over). Some organisms will not withstand such temperatures whether in sample bottles or in the Field Monitor units. In an emergency, Monitors may be incubated in the field by placing them next to the body for 20 hours.

MATERIALS REQUIRED FOR 100 TESTS

Supplies: 50 MH White Grid 037mm DE Field Monitoring Kits.

Equipment: 1 Sanitarian's Kit.
1 Field and Laboratory Incubator.

WATER TESTING IN THE FIELD — IN EIGHT STEPS

1. Cup thoroughly rinsed

2. Sample drawn through Monitor in inverted position

3. Monitor righted for last drops

4. Ampul tip broken — ampul inserted into Monitor

5. Ampul top broken — ampul lifted slightly.

6. Media drawn through Monitor with syringe. STOP THE INSTANT last few drops of media disappear

7. Replace caps.

8. Incubate 20 hours in inverted position

MILLIPORE FILTER CORPORATION

36 PLEASANT STREET, WATERTOWN 72, MASSACHUSETTS, U.S.A.

* Color illustrated booklet available.

Section Meetings

Alabama-Mississippi Section: The ninth annual meeting of the Alabama-Mississippi Section, held Oct. 21–24, 1956, at the Battle House, Mobile, Ala., was the biggest and most successful in the history of the Section. The total registration of 318, which included 101 ladies, exceeded the previous high of 313 at the Birmingham meeting in 1954. Many interesting and enlightening papers were presented at the five technical sessions, and all provoked much discussion. [A list of papers appears on p. 1571 of the December 1956 issue.]

The annual business meeting of the Section was held on Wednesday morning. After transaction of routine business the following new officers were elected: chairman—H. L. Burns, manager, Wholesale Supply Co., Jackson, Miss.; vice-chairman—W. E. Hooper, general manager of utilities, Sheffield, Ala.; and secretary-treasurer—C. M. Mathews, assistant superintendent, Public Utilities Commission, Yazoo City, Miss. Jess Lee Haley, manager of utilities, Clarksdale, Miss., was nominated for the Fuller Award.

Irving E. Anderson
Secretary-Treasurer

California Section: The 37th annual meeting of the California Section was held at San Diego Oct. 23–26, with 1,253 in attendance, including 518 members and 358 ladies. The headquarters hotel was the U. S. Grant, and technical sessions and exhibits were held in Balboa Park. The 53 exhibits were exceptionally well attended. The program was opened at the Kickoff Luncheon Wednesday noon. The highlight of the meeting was the Thursday session devoted to the subject of "California's New Water Department and Water Plan." There was a large attendance throughout the entire day's program, which ran from 9:15 in the morning until 4:30 in the afternoon. [A list of the papers presented at this and other technical sessions appeared on p. 1572 of the December 1956 issue.]

On Friday afternoon a general session included an address by President Paul Weir and the Section business meeting. At the business meeting M. J. Shelton (deputy director of the State Dept. of Water Resources) was elected chairman: Duncan A. Blackburn (chief engineer and general manager, Pasadena Water Dept.), vice-chairman; and C. P. Harnish (president of Southern California Water Co.), national director. New members of the Executive Committee are H. E. Butler, W. J. Hays, and C. K. Wells.

The ladies' program included Harbor Day, an excursion to the San Diego Harbor, luncheon at the Hotel del Coronado, and a tour of a major aircraft carrier; a second major ladies' event was Mexico Day, which included lunch at the El Cortez Hotel and a tour of the Tijuana shops.

The annual golf tournament, held Wednesday morning, had its usual success. The All Division Banquet was attended by 350 members, guests, and their ladies on Wednesday evening. The convention closed Friday evening with the manufacturers' annual banquet, followed by excellent entertainment and the presentation of awards.

(*Continued on page 78 P&R*)

(*Continued from page 76 P&R*)

Joseph M. Sanchis of the Los Angeles Dept. of Water & Power received the Elliott Award in recognition of his work on the Operators' Certification and Training Committee. Announcement was also made of the nomination of William C. Welmon of the Southern California Water Co. for the Fuller Award, in recognition of his work as chairman of the committee which reviewed and negotiated revisions in the New Rules and Standards for Construction of Water Works of the Public Utilities Commission, and for his services in the formation of the Business Management Div. of the California Section.

HENRY J. ONGERTH
Secretary-Treasurer

Florida Section: The annual meeting of the Florida Section was held Nov. 11–14 at the Daytona Plaza Hotel, Daytona Beach. This was a joint convention with the Florida Sewage & Industrial Wastes Assn. The meeting was unusually well attended with 331 registered.

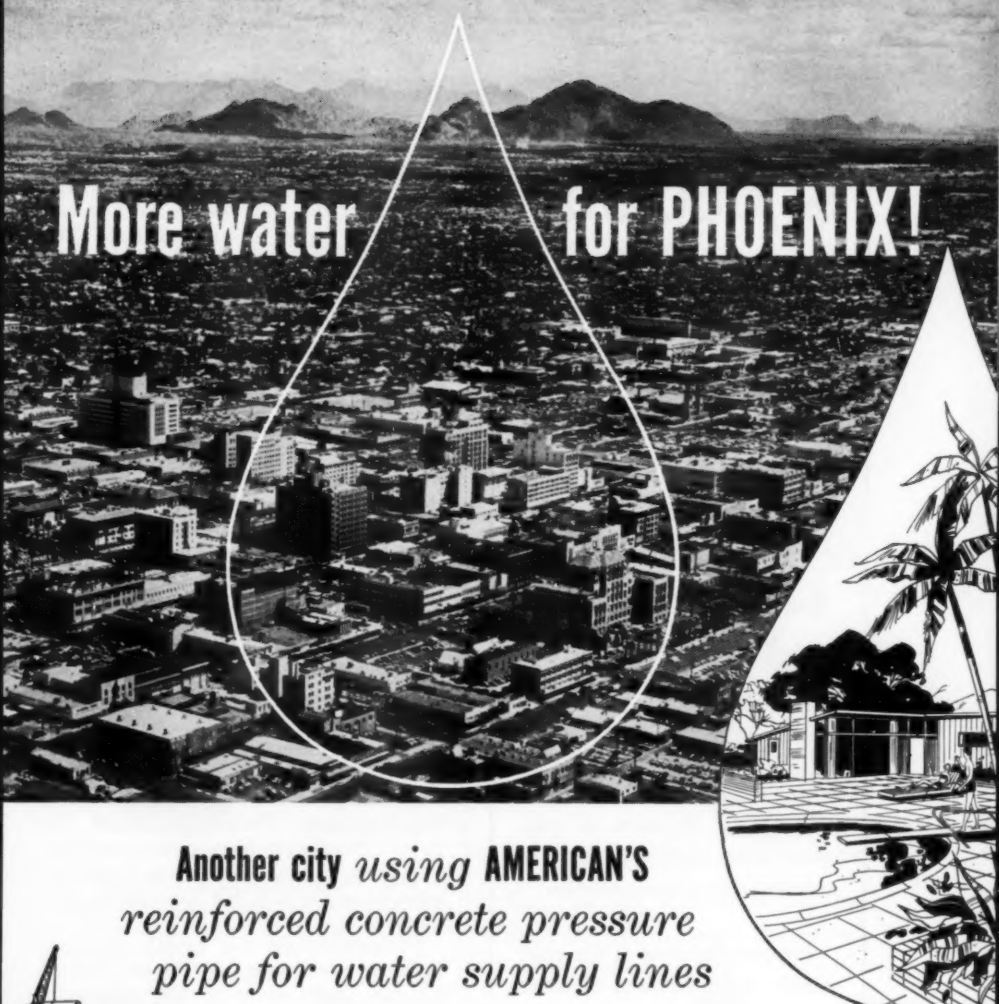
Wylie W. Gillespie was nominated for the Fuller Award for his outstanding work in water works engineering. Clifford E. Earls for the third time received the A. P. Black Cup for obtaining the largest number of new members during the year. Many exceptional papers were presented during the 3-day technical session. [A completed list appeared on pp. 1573–74 of the December 1956 issue.]

The following officers were elected: chairman—Stanley Sweeney, Pensacola; vice-chairman—Harold D. Overhiser, Mount Dora; national director—Fred A. Eidsness, Gainesville; trustees—John B. Sellers, Vero Beach, and Harvey T. Skaggs, Jacksonville.

At the business meeting, the members decided to publish a quarterly newsletter jointly with the Florida Sewage & Industrial Wastes Assn. and the Florida Water & Sewerage Operators Assn.

J. D. ROTH
Secretary-Treasurer

(*Continued on page 80 P&R*)



Another city *using* AMERICAN'S *reinforced concrete pressure pipe for water supply lines*

The City of Phoenix, Arizona is another of the rapidly growing cities of the Southwest which have faced tremendous water supply problems and have met them successfully. The population of Greater Phoenix has increased almost 50 per cent in the past five years. An annexation program is currently increasing the rapid expansion of the City of Phoenix which is one of the fastest growing cities in the nation.

During 1953 American Pipe and Construction Company, through Fisher Contracting Company, general contractors, supplied Phoenix with more than 37,000 feet of large diameter concrete pressure pipe for a line which increased the Phoenix primary feeder capacity from 100,000,000 MGD to 210,000,000 MGD. The pipe furnished was pre-stressed concrete cylinder pipe designed for the operating pressures established under specifications prepared by Yost & Gardner, consulting engineers for the City of Phoenix.

American has helped to meet the special problems faced by Phoenix water officials by designing and supplying reinforced concrete pressure pipe especially for conditions in the Phoenix area.

A recent merger with Hooper Concrete Pipe Company in Phoenix gives American another permanent plant from which to serve the cities of the Southwest.

American Pipe and Construction Company makes available 49 years of experience and extensive production facilities to help solve any water supply problem. There is a type of American pipe to meet any requirement. Write or phone for complete information.

American
PIPE AND CONSTRUCTION CO.

Concrete pipe for main water supply lines, storm and sanitary sewers, subaqueous lines

Mail address:
Box 3428 Terminal Annex, Los Angeles 54, Calif.

Main offices and plant:
4635 Firestone Blvd., South Gate, Calif., Phone LOrain 4 2511

District sales offices and plants:
Hayward and San Diego, Calif., Portland, Ore., Phoenix, Ariz.

(*Continued from page 78 P&R*)

New Jersey Section: The annual fall meeting of the New Jersey Section was held at the Hotel Madison, Atlantic City, on Oct. 18–20, 1956, with the roar of the Atlantic Ocean in the background as a reminder that "Water Is Our Business." Registration was 351. The many ladies attending had a luncheon get-together followed by rides in the famed Atlantic City boardwalk rolling chairs along the ocean.

The program included many worthwhile technical papers, and the sessions, ably planned by Program Chairman Alfred Anderson, were well attended. [A list of papers presented appears on p. 1577 of the December 1956 issue.]

The annual banquet was a success. Vice-President Merryfield presented Life Membership certificates to P. S. Wilson, Martin E. Flentje, and John Schlicht. The Section now has 23 Life Members. Prof. Merryfield indicated that the Pacific Northwest Section, of which he is a member, had about the same total membership as New Jersey, and Secretary-Treasurer Pleibel challenged the Pacific Northwest Section to a membership contest, with the results to be announced at the AWWA Convention next May.

Nomination for the greatly esteemed Fuller Award went to George Norcom for his contribution to the science of water purification, much to the gratification of the membership. A fitting tribute was paid to Cy Tygert, retiring after 17 years as the Section's devoted and hard working secretary-treasurer, by Director Alfke, who also presented him with a gift from the Section. The guests were greatly entertained by an accordionist, a magician, and a splendid male quartet, which did much to encourage the membership to lend their voices, and the air was warm with the sounds of good fellowship.

The newly elected officers are: chairman—Harold M. Ohland, Jersey City; vice-chairman—Martin E. Flentje, Mer-

(*Continued on page 82 P&R*)

(*Continued from page 80 P&R*)

chantville; director—Charles J. Alfke, Weehawken; trustees—John J. Reager, Perth Amboy, and Lewis W. Klockner, Trenton; and secretary-treasurer—Albert F. Pleibel, Maplewood.

The 3-day meeting ended Saturday noon with the ever popular Superintendents' Breakfast. John Reager presided, with Oscar Newquist as leader. As usual they did a very excellent job, judging from the enthusiasm engendered in the discussion of such subjects as hydrant painting, meter reading and collections, meter ownership, and pipeline cleaning. So concluded a very enjoyable meeting.

ALBERT F. PLEIBEL
Secretary-Treasurer

New York Section: The New York Section held its annual fall meeting at the Sagamore Hotel, Bolton Landing, on Sep. 12–14, 1956. The total record registration was 429. [A list of the papers presented appears on p. 1578 of the December 1956 issue.]

The Water & Sewage Works Manufacturers Assn. sponsored a very enjoyable cocktail party, with dancing on the terrace. Following the banquet there was dancing in the Colony Club, including a dance contest at which Harry Jordan, Lou Russo, and Clarence Hamel made an outstanding showing of their talents. A midnight picnic was held at the lake front, with plenty of charcoal-broiled hamburgers and hot dogs, accompanied by singing and music.

Jim Haberer and Bud Moore of the Section's golf committee awarded the golf prizes. Among the high scorers were Les Hart, R. J. Bussell, Wentworth Smith, Garner Tripp, Dale Lawson, Bill Johnson, Harvey Howe, and Ed Cloonan.

(*Continued on page 84 P&R*)

(*Continued from page 82 P&R*)

Liz Hart took high honors for the ladies' golf.

Glens Falls provided a lake steamer for a delightful trip around Lake George, and Garner Tripp, superintendent at that city, deserves a hearty pat on the back for his excellent job of heading up the local committee of arrangements.

KIMBALL BLANCHARD
Secretary-Treasurer

Ohio Section: The Ohio Section held its eighteenth annual conference in the Commodore Perry Hotel, Toledo, on Sep. 19–21, 1956. Registration this year was about normal, with 253 men and 68 ladies attending. M. W. Tatlock, program chairman, with his committee (M. L. Riehl, Bob Holt, T. R. Lathrop, and C. H. Raubenolt) provided an interesting technical program on all phases of water works operations. [A list of the papers presented appears on pp. 1578–79 of the December 1956 issue.]

The WSWMA cocktail hour started the social activities Thursday evening and provided an enjoyable hour for everyone to get better acquainted. Following was the annual banquet, with a large attendance (320). A Life Membership certificate was presented to William L. Havens. Wendell R. LaDue awards were then given to George E. Barns, Eugene D. Barstow, and J. V. Carty. The Fuller Award Committee nominated Charles Edwin Beatty. The program was concluded with Countess Maria Pulaski A/K/A Martin David Hughes as the guest speaker. Mrs. C. S. Finkbeiner and her Ladies' Arrangements Committee provided a get-acquainted tea Wednesday afternoon and special activities for Thursday which proved to be a most enjoyable program for the ladies.

New officers elected were: chairman—M. W. Tatlock, Dayton; vice-chairman—H. C. Growdon, Portsmouth; secretary-treasurer—M. E. Druley, Wilmington; trustee—Frank Ruck, Troy; and director—Donald D. Heffelfinger, Alliance.

The conference program was concluded Friday afternoon with a lunch and inspection trip to Toledo's new filtration plant.

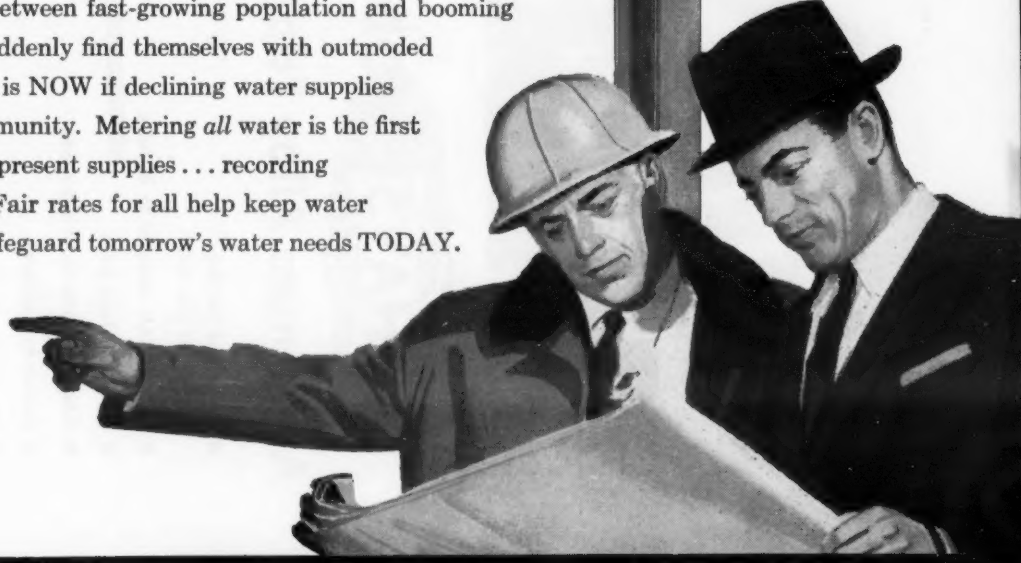
M. E. DRULEY
Secretary-Treasurer

Southwest Section: The Southwest Section held its 45th annual meeting in Little Rock, Ark., Oct. 14–17, 1956, with Leslie A. Jackson, manager-engineer of the Little Rock Water Works System, serving as host. There was a record registration of 888. Three full days were devoted to program papers and discussions, and the program was enthusiastically received. Winthrop Rockefeller, chairman, Arkansas Industrial Development Commission, Little Rock, was a featured speaker, on the topic, "Water and Industry." [A complete list of papers presented appears on p. 1580 of the December 1956 issue.]

The following new officers were elected: director—Karl F. Hoefle, Forrest & Cotton, Dallas, Tex.; chairman—Haskell R. Street, assistant superintendent, water and sewage treatment, El Paso, Tex.; vice-chairman—Quintin B. Graves, professor, Dept. of Civil Engineering, Oklahoma A&M College, Stillwater; trustees—John Luce (superintendent, Fort Smith Water Co., Fort Smith, Ark.), James L. Love (superintendent of water and sewage, Lafayette, La.), Hendon M. Crane (assistant sanitary engineer, State Dept. of Health, Oklahoma City), and James C. Deal (director of production, Water Board, San Antonio, Tex.). The following were appointed to serve on the Board of Trustees: Robert W. Harding, Publication Committee chairman, San Antonio; William F. Hoffmann Jr., Manufacturers Committee Chairman, Dallas; and Leslie A. Jackson.

J. Richard Pierce, vice president and general manager, General Waterworks Corp., Pine Bluff, Ark., was nominated to receive the Fuller Award. Frank H. Robertson II, Oklahoma City, and Dorothy Wedeman, San Antonio, were recipients of the Egmont S. Smith Memorial Scholarship Fund Award.

LESLIE A. JACKSON
Secretary-Treasurer



(*Continued from page 52 P&R*)

B. V. Bhoota, of Bombay, has been named to the board of directors of Dorr-Oliver (India) Ltd. Dr. Bhoota has been associated with the organization and the sanitary field in India since 1946.

F. B. Leopold Co. has moved its operations to new and larger quarters at Zelienople, Pa. The firm was formerly located in Pittsburgh. Its new facilities will house the company's offices, as well as manufacturing equipment.

Max H. Richter Jr., of New Orleans, and George Ries, of Cleveland, have been appointed sales engineers by Peerless Pump Div. of Food Machinery & Chemical Corp., Los Angeles.

Alco Products, Inc., has completed a $2,000,000 building and expansion program at its Beaumont, Tex., plant. The remodeling and additions involved office, warehouse, fabrication, assembly, and machine shop facilities.

Space champs of 1956 as far as the water works field is concerned were the drought and fluoridation—the one catastrophic enough, the other controversial enough to rate high priority for the newspaper columns of the nation. For the unprecedented amount of attention that such newspaper coverage brought to public water supplies last year we must, indeed, be grateful, but we could wish that the stars of our space were happier ones than absence and agitation. At the moment, however, it appears that the a's will have it again in 1957. The drought in the Southwest and the Great Plains is the worst in 700 years, affecting approximately 40 per cent of the nation's croplands and drying up water supplies from Arizona to Missouri and from the Dakotas to the Rio Grande. Meanwhile, though water supplies for well over 30,000,000 people are now being fluoridated, the same arguments concerning the merits and demerits continue hotter than ever—even where the decision has been made and the action taken. In short, the price of free newspaper space seems appallingly high!

George E. Warren, president of Southwestern Portland Cement Co., Los Angeles, has been elected chairman of the board of Portland Cement Assn. Mr. Warren, who has served on the board since 1953, succeeds Emory M. Ford, chairman of Huron Portland Cement Co., Detroit.

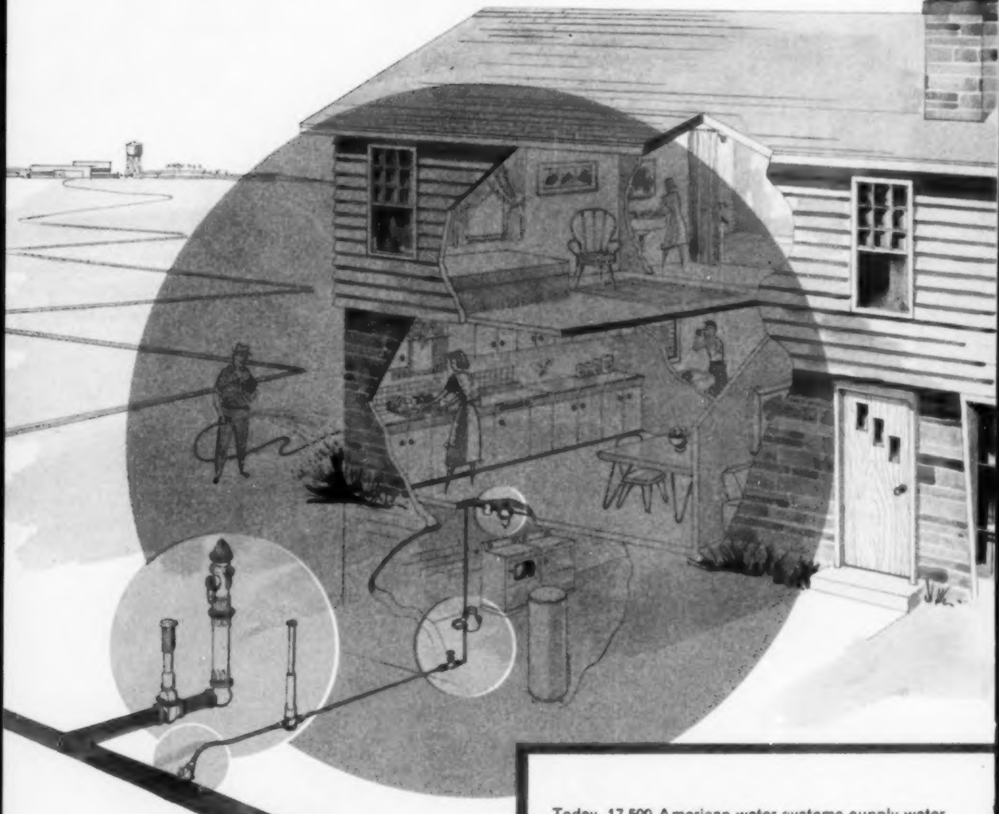
Badger Meter Mfg. Co. has opened a new Southwest area branch plant with complete repairing and testing facilities in the Brook Hollow industrial district of Dallas, Tex. The plant is under the supervision of Norman H. Abrams, Southwest sales manager.

Louis A. Geupel is no longer with R. Stuart Royer & Assocs., Richmond, Va., as reported in the 1956 *Directory*. He is chief of the Water & Sewage Branch, Utilities Div., Maintenance Directorate, Office of Assistant Secretary of Defense (Properties & Installations), Pentagon Bldg., Washington, D.C.

William W. Adkins, formerly director of the Burlington, N.C., Utilities Dept., has joined the Greenville, S.C., Water Works, where he will be associated with Superintendent John L. Hawkins.

(*Continued on page 90 P&R*)

Serving 112,000,000 Am



Today, 17,500 American water systems supply water to 112,000,000 homes and industries in the 48 states. An average of 154 gallons of water per person is used each day for a thousand and one purposes in the average American home.

American Homes and Industries

Today's water industry is a far cry from the oaken bucket of a hundred years ago. A look backward reveals remarkable growth and development in the field of water distribution.

The first public water system was in Boston in 1642; and, 150 years later, only 17 systems were in operation in America. In 1829, water was first treated, at Lynchburg, Virginia, by settling basins that removed silt from water. Fifty years elapsed before the first practical method of treatment by coagulation, sedimentation and filtration was developed to improve the water supply of Vicksburg, Mississippi.

Thus, the last 75 years have seen the development of the modern water industry and methods of treatment and distribution.

It was previous to this period that Hieronymous Mueller founded Mueller Co. in 1857 at Decatur, Illinois. He was appointed city plumber of Decatur in 1871. This led to his invention of the Mueller tapping machine in 1872, improved models of which are now in use throughout the industry.

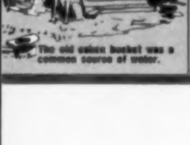
Another milestone was the use of 42" metal pipe for service at Newark, New Jersey in 1892. Wooden mains were gradually replaced with long-lasting cast-iron pipe. Copper pipe, introduced in 1924, is now widely used in water systems.

A step that guided the development and growth of the industry was the formation of the American Water Works Association in 1881. Professional water works men banded together in an association to share experiences and work out problems for the benefit of all. For 75 years, this organization has led growth and progress of the industry. Mueller Co. was one of the first five associate members.

The 656 water systems, supplying service to 10,000,000 consumers in 1880, multiplied to the modern network of 17,500 systems supplying 112,000,000 homes and industries today.

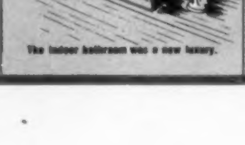
Electric power producers and industrial users are the largest consumers of water, each requiring 60 billion gallons daily. Individual consumers require only 17 billion gallons each day. 5.5 billion gallons are consumed in rural areas. This volume portrays the growth in our water systems, which, just 70 years ago, provided only 40.9 billion gallons daily.

Water works construction kept pace with the growing need. During the past quarter century, 4,575 systems expanded their services and 16,000 new systems were installed. Construction budgets set an all-time high in 1956 of about $272,908,000. This construction program is brought about by major cities modernizing and enlarging their systems and by the increasing need for water service in new suburban areas.



The old oaken bucket was a common source of water.

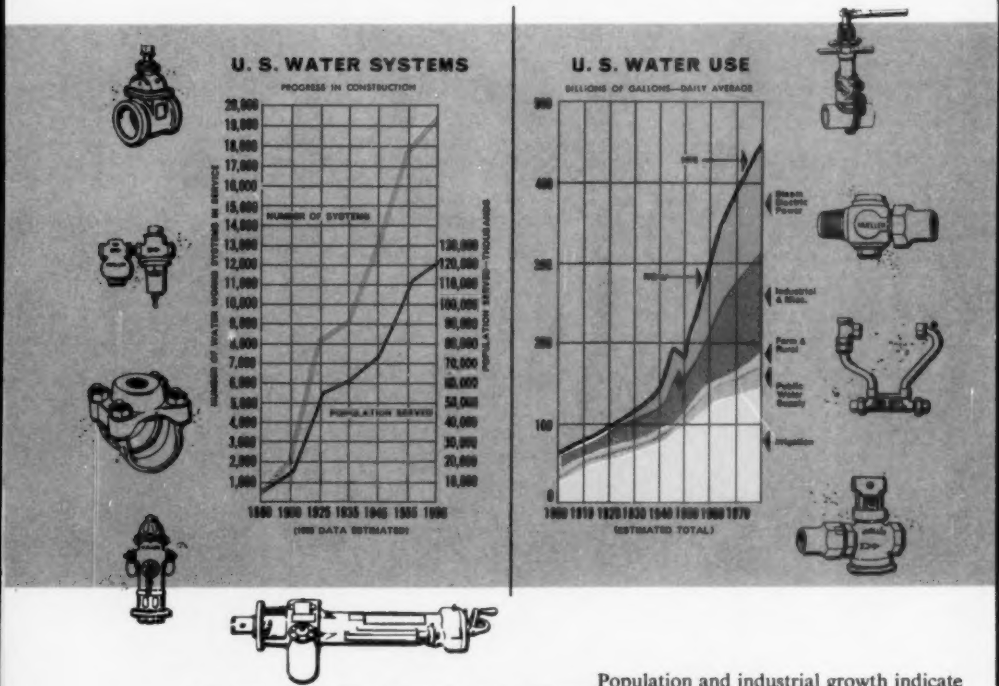
Waiting in line at the community water pump.



The indoor bathroom was a new luxury.

Modern water facilities are utilized for a thousand purposes.

What's ahead for Water?



Population and industrial growth indicate a 73 per cent increase in water usage during the next 20 years.

Daily usage is expected to reach 284 billion gallons by 1975, twice the present-day consumption! This increase is created by a population forecast of 206 million in 1975, and a 50 per cent jump in industrial usage.

Expansion of the water industry is expected to continue, with construction projects and increased budgets enabling the industry to provide adequate water for future needs.

New techniques may aid in supplying requirements. Replenishing ground water by artificial means could store water underground with negligible loss. Artificial induction of precipitation may help. Research, in processing sea water, could provide a new source of water.

Careful planning and allocation of resources will be required to supply future needs. Efficient systems, utilizing proper service equipment, will deliver water with minimum loss.

The tremendous progress of the water industry is proof of its ability to meet the challenge of the future.

MUELLER CO. **DECATUR, ILL.**

Factories at: Decatur, Chattanooga, Los Angeles; In Canada: Mueller, Limited, Sarnia, Ontario

Since 1857

(*Continued from page 88 P&R*)

Infilco Inc. has announced the election of A. A. Kalinske and E. G. Kominek as vice-presidents. Mr. Kalinske is director of research, Mr. Kominek general sales manager. Another recent personnel change in the firm was the appointment of O. E. Baker as manager of the Industrial Div., succeeding A. C. Embshoff, who retired after 35 years.

Moro M. Borden, engineering consultant, Simplex Valve & Meter Co., died Nov. 16, 1956, at his home in Collingswood, N.J. He was 79. Starting his career with American Pipe & Construction Co. in 1902, he became chief engineer for Simplex when the company was formed in 1905. From 1914 to 1938 he served as general manager, being named vice-president in charge of engineering in the latter year. In 1946 he became engineering consultant to the firm, a position he held until his death.

A Life Member of AWWA (joined in 1912), Mr. Borden also belonged to ASME and Franklin Institute of Philadelphia.

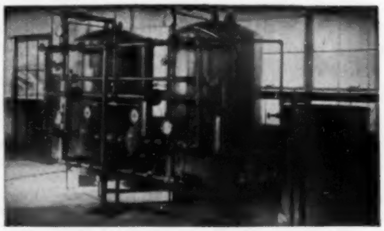
John C. Schlicht, treasurer and construction superintendent of Hackensack Water Co., died Dec. 6, 1956, at the age of 59. Born in North Bergen, N.J., he attended public schools there and lived in West New York, N.J., and Hackensack, N.J., before moving to Hillsdale, N.J., 7 years ago. A Life Member of AWWA, he joined in 1926.

Roberts Filter *means...*

MUNICIPAL WATER PURIFICATION

The combined capacity of Roberts-equipped filtration plants is well over 5 billion gallons (5,000,000,000) per day. Regardless of the size of the plant or the nature of the filtration problem, Roberts Filter can be depended upon for equipment that is reliable in years of service.

INDUSTRIAL WATER RECTIFICATION

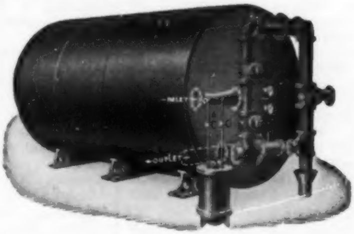


Water treatment has long been a specialty of Roberts Filter. Zeolite water softeners are guaranteed to meet all requirements for which recommended, and are available in a wide range of capacities. Roberts water conditioning equipment is widely used to control precisely the desired chemical content of water for industrial use.

SWIMMING POOL RECIRCULATING SYSTEMS

The combination of thoroughly clarified water and efficient recirculation are features for which Roberts pools are famous. Systems for both outdoor and indoor pools are designed and installed by men long experienced in the conditions peculiar to a successful swimming pool installation.

PRESSURE FILTERS



Closed pressure filters have wide usage where gravity filters are not justified. Roberts vertical filters are available in standard types from 12" to 96" diameter; horizontal pressure filters are all 8'0" in diameter and in varying lengths from 10'0" to 25'0".

When you think of good water—think of Roberts Filter

MECHANICAL EQUIPMENT BY ROBERTS FILTER MFG. CO DARBY, PENNA.

Roberts Filter

Manufacturing Company • Darby, Penna.

NEW MEMBERS

Applications received Nov. 1–31, 1956

Abrahamson, Kenneth H., *see* Giffels & Vallet

Akana, Theodore K., Field Supt., Suburban Water System, Rm. 111, City Hall, Honolulu, T.H. (Oct. '56) *M*

Alexander, Lewis E., Repr., Hersey Mfg. Co., South Boston 27, Mass. (Oct. '56) *MPD*

Alling, Raymond M., Pres., Bear Constr. Co., Inc., 2842 W. Henrietta Rd., Rochester 20, N.Y. (Oct. '56) *D*

Amack, Russell B., 223 Marker St., Long Beach 5, Calif. (Oct. '56)

Anderson, Roy L., Exec. Secy., California Water Assn., 333 Grand Ave., South Pasadena, Calif. (Oct. '56)

Baker, E. George, Asst. Sales Mgr., Mueller Co., 2801 E. 12th St., Los Angeles 23, Calif. (Oct. '56) *D*

Barnewold, Otto A., Supt., Jefferson Parish Water Works No. 3, Box 212 A, Belle Terr Rd., Marrero, La. (Oct. '56)

Beacon Water Dept., Wesley W. Tompkins, Comr. of Public Works, Tioronda Ave., Beacon, N.Y. (Munic. Sv. Sub. Oct. '56) *R*

Bott, Roderick F., Public Health Engr., San Diego County Dept. of Public Health, 3330 Congress St., San Diego, Calif. (Oct. '56) *RPD*

Boyer, Floyd H., Box 1751, Denver 1, Colo. (Oct. '56) *MD*

Brewer, William Joseph, Asst. Supt., Water Works, 304 Municipal Bldg., Dallas, Tex. (Oct. '56) *M*

Burks, Neal Jack, Fire Chief, 107 W. Front St., Buchanan, Mich. (Oct. '56) *PD*

Burrows, John E., Pres., Burrows Well Drilling Co., Inc., 643 Squaw Brook Rd., North Haledon, N.J. (Oct. '56) *R*

Campbell, Ralph, Water Supt., 916 Texas Ave., Lubbock, Tex. (Oct. '56) *M*

Carey, Donald Edmund, Asst. Engr., Elizabethtown Water Co., Consolidated, 22 W. Jersey St., Elizabeth 4, N.J. (Oct. '56) *D*

Carr, Keith; *see* Gibsonburg (Ohio) Water Works

Catlin, William G., Civ. Engr., Helix Irrigation Dist., 4769 Spring St., La Mesa, Calif. (Oct. '56)

Conaway, Ross Keller, Asst. Distr. Supt., Water Dept., 1810 Highland Ave., Tampa 2, Fla. (Oct. '56) *D*

Crosby, Edwin S., Asst. Prof., Univ. of California, Berkeley 4, Calif. (Oct. '56) *RP*

Cucamonga County Water Dist., Norman G. Hixson, Gen. Mgr., 9314 San Bernardino Rd., Cucamonga, Calif. (Munic. Sv. Sub. Oct. '56) *MRPD*

Elder, Elmus E., Gen. Foreman, Water Dept., Div. of Distr., 1970 B. St., San Diego, Calif. (Oct. '56) *D*

Elliott, William Thomas, Supt., Water Production, Denton, Tex. (Oct. '56) *P*

Fort Madison Munic. Water Works, Frank W. Freitag, Supt., 707—7th St., Fort Madison, Iowa (Munic. Sv. Sub. Oct. '56) *MPD*

Fox, Carl L., Jr., Vice-Pres., Ward K. Stallings Co., 3120 Maple Dr., N.E., Atlanta, Ga. (Oct. '56) *P*

Freitag, Frank W.; *see* Fort Madison (Iowa) Munic. Water Works

Geurin, Bill, Salesman, Neptune Meter Co., 315 Cole St., Dallas, Tex. (Oct. '56)

Gibsonburg Water Works, Keith Carr, Supt., 400 S. Main St., Gibsonburg, Ohio (Corp. M. Oct. '56) *MP*

Giffels & Vallet, Inc., Kenneth H. Abrahamson, Mech. Engr., 1000 Marquette Bldg., Detroit 26, Mich. (Corp. M. Oct. '56)

Graham, Ethelbert H., Jr., Staff Engr., Koebig & Koebig, 3242 W. 8th St., Los Angeles 5, Calif. (Oct. '56) *PD*

Grissom, Dick, Salesman, Bowles & Edens Supply Co., 603—2nd Ave., Dallas, Tex. (Oct. '56)

Hall, David Michael, Staff Engr., Koebig & Koebig, 3242 W. 8th, Los Angeles 5, Calif. (Oct. '56) *D*

Halpenny, Arthur S., Gen. Sales Mgr., Byron Jackson of Canada, Ltd., Box 180, Station H, Toronto 13, Ont. (Oct. '56)

Hansel, John P., Sales Mgr., Filtrine Mfg. Co., 60 W. Prospect St., Waldwick, N.J. (Oct. '56) *RPD*

Hanson, V. P., Supt. of Utilities, Pond Creek, Okla. (Oct. '56)

Harding, Joseph P., Electric Dept. Supt., Box 29, Tell City, Ind. (Oct. '56) *P*

Harlan, D. W., Water Supt., Water Works, Diggott, Ark. (Oct. '56) *MRPD*

Haslop, Norman E., Sales Engr., Box 475, North Ridgeville, Ohio (Oct. '56) *D*

Hebert, Floyd E., Water Supply Supervisor, Water Dept., 2800 Airport Way, Seattle 4, Wash. (Oct. '56) *MD*

Heyn, H. Bunsen, Regional Mgr., Pacific Pipe Div., Johns-Manville Sales Corp., 816 W. 5th St., Los Angeles, Calif. (Oct. '56)

Hicks, B. F., Supt. of Utilities, Brooklyn, Iowa (Oct. '56) *MRD*

Hixson, Norman G.; *see* Cucamonga County (Calif.) Water Dist.

Hollenbach, Howard F., San. Engr., Asst., Dept. of Water & Power, Box 3669 Terminal Annex, Los Angeles 54, Calif. (Oct. '56) *R*

Holman, Gayle Roydon, Civ. Eng. Assoc., Dept. of Water & Power, 410 Ducommun St., Los Angeles 12, Calif. (Oct. '56) *MD*

Houston, L. Neale, Civ. Eng. Assoc., Dept. of Water & Power, Box 3669 Terminal Annex, Los Angeles 54, Calif. (Oct. '56) *D*

Howell, Charles L., Director, Dental Div., State Board of Health, 1330 W. Michigan St., Indianapolis 7, Ind. (Oct. '56)

Jacob, Earl S., Water Maint. Supervisor, Water Works Board, Montgomery, Ala. (Oct. '56) *M*

Jacobs, M. Wayman; *see* Parker (Ind.) Water Works

Johnson, James L., Water Supt., Box 371, Wilmer, Tex. (Oct. '56) *MRPD*

Johnson, Robert Morley, Salesman, Hays Mfg. Co., 734 Niwitz Dr., Jackson, Miss. (Oct. '56) *D*

Jones, Allen H., Asst. Chief Engr., San Diego County Water Authority, 2750—4th Ave., San Diego, Calif. (Oct. '56) *D*

Keller, James H., Director of Utilities, Utilities Dept., Box 2095, Henderson, Nev. (Oct. '56) *MRPD*

Kheyltash, Anwar, Field Engr., Litchfield-Whiting & Assocs., Teheran, Iran (Oct. '56) *RPD*

Lawrence, Frank J., Area Supervisor, Florida Keys Aqueduct Com., Key West, Fla. (Oct. '56) *D*

Lee, Phillip Benjamin, Civ. Eng. Assoc., Water Distr. Div., Dept. of Water & Power, Box 3669 Terminal Annex, Los Angeles 54, Calif. (Oct. '56) *MD*

Lee, Robert D., Dist. Sales & Service Mgr., Simplex Valve & Meter Co., Lancaster, Pa. (Oct. '56) *PD*

Lee, William Frank, Vice-Pres. & Secy., Lee Constr. Co., Box 3608, Charlotte 3, N.C. (Oct. '56) *RP*

Lowles, Amos W., Supt., Water Dept., Box 482, Port Orange, Fla. (Oct. '56) *MRPD*

Magoffin, Linn E., Div. Engr., San Gabriel Valley Div., California Water & Telephone Co., 2116 Huntington Dr., San Marino, Calif. (Oct. '56) *MD*

Mangrum, Paul, Meter Supt., Grand Prairie, Tex. (Oct. '56)

Maudlin, Delbert R., Supt., Alco Water Service, 470 Williams Rd., Salinas, Calif. (Oct. '56) *M*

McBain, Harmon; *see* Middleburgh (N.Y.)

McCain, E. A.; *see* Park Hill–Sylvan Hills (Ark.) Water Dists.

Mickle, James D., Cons. Engr., 1 Kelley Bldg., Fort Smith, Ark. (Oct. '56) *PD*

Middleburgh, Village of, Harmon McBain, Comr. of Power & Water, Middleburgh, N.Y. (Munic. Sv. Sub. Oct. '56) *D*

(*Continued on page 94 P&R*)

(Continued from page 92 P&R)

Miller, Earl W., Sales Engr., Bowles & Edens Supply Co., 603—2nd Ave., Dallas, Tex. (Oct. '56) *D*

Mindt, Frederick E.; *see* New Hampshire Public Utilities Com.

Murray, Charles Robert, Supt., Water & Sewage, Dept. of Public Works, 3 Lake Ave., Saratoga Spring, N.Y. (Oct. '56) *MRPD*

Neal, George H., Supt. of Public Utilities, Sibley, Iowa (Oct. '56) *MRPD*

Nelson, John T., Supt., Hattiesburg, Miss. (Oct. '56) *MPD*

New Hampshire Public Utilities Com., Frederick E. Mindt, Chief Engr., State House Annex, Concord, N. H. (Corp. M. Oct. '56) *MRPD*

Nichols, Paul L.; *see* Sonoma County (Calif.) Flood Control and Water Conservation Dist.

Niemann, August Henry, Jr., Civ. Eng. Asst., Dept. of Water & Power, 207 S. Broadway, Los Angeles, Calif. (Oct. '56) *D*

O'Brein, Waller, Sales Eng., Ulrich Chem. Co., 2640 W. Minnesota St., Indianapolis, Ind. (Oct. '56) *P*

Offner, William Bernard, Civ. Eng. Asst., Dept. of Water & Power, Los Angeles 13, Calif. (Oct. '56) *M*

Orange Cove Water Dept., R. Curtis Whisenhunt, Supt., Water Dept., 555—6th St., Orange Cove, Calif. (Munic. Sv. Sub. Oct. '56) *MP*

Paddock, L. V., Sales Mgr., Alladdin Labs., Inc., New York, N.Y. (Oct. '56) *PD*

Park Hill–Sylvan Hills Water Dists., E. A. McCain, Supt., 3427 Magnolia St., North Little Rock, Ark. (Munic. Sv. Sub. Oct. '56) *D*

Parker Water Works, M. Wayman Jacobs, Clerk-Treas., Parker, Ind. (Corp. M. Oct. '56) *D*

Parkhurst, C. K., Supt., Water Dept., Elkhart, Ind. (Oct. '56) *MPD*

Patt, Winfield Chandler, Jr., Service Engr., B-I-F Industries, Inc., 6230—3rd St., N.W., Washington 11, D.C. (Oct. '56) *P*

Paulling, Bennie Max, Supt. of Utilities, 1000 Lyttleton St., Camden, S.C. (Oct. '56)

Pereda B., Clemente, Civ. & San. Engr., General Eng. Sec., Creole Petroleum Corp., Caracas, Venezuela (Oct. '56) *RPD*

Peterson, Sidney E., Supt. of Distr., 708—3rd St., S.E., Cedar Rapids, Iowa (Oct. '56) *D*

Pohl, Rudolph, Supt. of Utilities, Gowrie, Iowa (Oct. '56) *MRD*

Poole, William, Supt., Water Dept., Fort Branch, Ind. (Oct. '56) *MPD*

Ray, Albert M., Chief Operator, Water Dist. No. 3, Pineville, La. (Oct. '56) *P*

Ray, Robert, Mayor, Gas City, Ind. (Oct. '56) *MPD*

Reardon, Robert; *see* Scottsburg (Ind.) Dept. of Water Works

Reed, Gerald, Foreman, Water Dept., Madison, Ind. (Oct. '56) *D*

Reid, Hubert, Box 215, Leachville, Ark. (Oct. '56) *P*

Rheault, A. Gene, Civ. Engr., James M. Montgomery, 535 E. Walnut St., Pasadena, Calif. (Oct. '56) *R*

Richardson, Jerome, Jr., Cons. Mech. Engr., Loolootee, Ind. (Oct. '56)

Richardson, Joseph Henry, Florida Keys Aqueduct Com., Box 552, Key West, Fla. (Oct. '56) *M*

Riggle, William, Board Pres., Bruceville, Ind. (Oct. '56) *MRPD*

Rosenberger, Raymond J., Cons. Engr., H. K. Ferguson Co., 408 Glen Park Dr., Bay Village, Ohio (Oct. '56)

St. John, H. S., Mgr., Utilities Dept., Troy, Ala. (Oct. '56) *MD*

Schnaus, Robert, Chairman, Utilities Service Board, Jasper, Ind. (Oct. '56) *MRPD*

Schroff, Oscar Albert, Asst. Supt., Water Production Div., San Diego, Calif. (Oct. '56) *MD*

Scottsburg Dept. of Water Works, Robert Reardon, Supt., 55 N. 1st St., Scottsburg, Ind. (Munic. Sv. Sub. Oct. '56) *MRPD*

Seaholm, W. E., Cons. Engr., Seaholm & Levander, 815 Airport Blvd., East Austin Station, Austin, Tex. (Oct. '56) *RPD*

Shives, Thomas W., Public Health Engr., State Dept. of Health, Baltimore, Md. (Oct. '56)

Sisson, Howard H., Southern Sales, American Cast Iron Pipe Co., Box 2603, Birmingham 2, Ala. (Oct. '56) *PD*

Skinner, Ernest H., Water Supt., Okmulgee, Okla. (Oct. '56) *MRPD*

Skinner, Raymond E., Admin. Asst., Water Dept., Rm. 273, Civic Center, San Diego 1, Calif. (Oct. '56) *M*

Sliwa, John P., Borough Engr., Madison, N.J. (Oct. '56) *MD*

Smith, Malcolm P., Salesman, Alladdin Labs. Inc., 68 Williams St., New York 5, N.Y. (Oct. '56) *P*

Smith, Oscar T., Salesman, 1100 N. Adams, Henderson, Ky. (Oct. '56)

Sonoma County Flood Control and Water Conservation Dist., Paul L. Nichols, Chief Engr., 502 Rosenberg Bldg., Santa Rosa, Calif. (Corp. M. Oct. '56) *MRPD*

Sparkman, Glenn E., Water Supt., Canyon, Tex. (Oct. '56)

Steadman, Roger G., Sec. Head, Process Control—Chem., Allen B. DuMont Labs., Inc., 750 Bloomfield Ave., Clifton, N.J. (Apr. '56) *P*

Steel, Wilbur Z., Foreman, Water Dept., Columbia City, Ind. (Oct. '56)

Stempel, Philip C., Mgr., Des Moines Sub-Branch, Fairbanks Morse & Co., 2017 Dean Ave., Des Moines, Iowa (Oct. '56) *RD*

Steward, W. R., Jr., Asst. Supt., Water & Sewer System, Searcy, Ark. (Oct. '56)

Stone, George B., Florida Keys Aqueduct Com., Box 552, Key West, Fla. (Oct. '56) *D*

Storrie, James C., City Hall, Denton, Tex. (Oct. '56) *M*

Sult, Cliff, Supt. of Light & Water, New Carlisle, Ind. (Oct. '56) *MPD*

Sutton, Raymond L., Sales Repr., Traverse City Iron Works, South Bend, Ind. (Oct. '56) *MRPD*

Swain, Richard M., Dis. Sales Mgr., Penn Salt Mfg. Co., 1828 Carew Tower, Cincinnati 2, Ohio (Oct. '56)

Tait, Harold L., Supt., Water & Light Dept., Evansville, Wis. (Oct. '56) *MP*

Tarvin, Ray, Supt., Water Dept., Odon, Ind. (Oct. '56)

Tengdin, E. T., Pres., Plains Utilities Co., 501 Commercial National Bank Bldg., Kansas City 1, Kan. (Oct. '56) *MD*

Thacker, J. Edward, Distr. Engr., Water Dept., 201 City Hall, Nashville, Tenn. (Oct. '56) *MPD*

Thomas, Terry A., Jr., T & H Pump & Equipment Co., 21 N.W. 2nd St., Evansville, Ind. (Oct. '56) *RD*

Tillman, C. A., Purchasing Agent, General Waterworks Corp., Pine Bluff, Ark. (Oct. '56) *M*

Tompkins, Wesley W.; *see* Beacon (N.Y.) Water Dept.

Tucker, I. Jack, Supt., Corbin Water Dist. No. 4, Box 62, Greenacres, Wash. (Oct. '56) *MD*

Van Zandt, Khleber M., IV, Asst. Chemist, Water Dept., Box 870, Fort Worth, Tex. (Oct. '56) *P*

Vincent, Keith Earl, Jr. Engr., Water Dept., Fresno, Calif. (Oct. '56) *RPD*

Wakefield, Arthur, Supt., Water Dept., Madison, Ind. (Oct. '56) *MRPD*

Walters, Robert S., Sales Repr., Badger Meter Mfg. Co., 2940 Leonis Blvd., Los Angeles 58, Calif. (Oct. '56) *D*

Warrington, Sam L., Chief, Training Sec., Div. of San. Eng., State Dept. of Health, Austin, Tex. (Oct. '56) *MRPD*

Waters, Forest O., Corrosion Engr., Water Dept., Balboa Park, San Diego, Calif. (Oct. '56) *RPD*

Weddington, George L., Shop Foreman, Water Works, Waco, Tex. (Oct. '56)

Whisenhunt, R. Curtis; *see* Orange Cove (Calif.) Water Dept.

Whitmer, Lee, Sales, Crane Co., 209 N. 9th St., Terre Haute, Ind. (Oct. '56) *MD*

Wicht, Edwin W., Public Relations, Eng. Service Corp., 1127 W. Washington Blvd., Los Angeles, Calif. (Oct. '56) *MRPD*

Wong, Albert K., Civ. Eng. Assoc., Water Distr. Div., Dept. of Water & Power, 410 Ducommun St., Los Angeles 12, Calif. (Oct. '56) *D*

Woodward, Kenneth G., Civ. Engr., 7½ E. Main St., Webster, N.Y. (Oct. '56) *D*

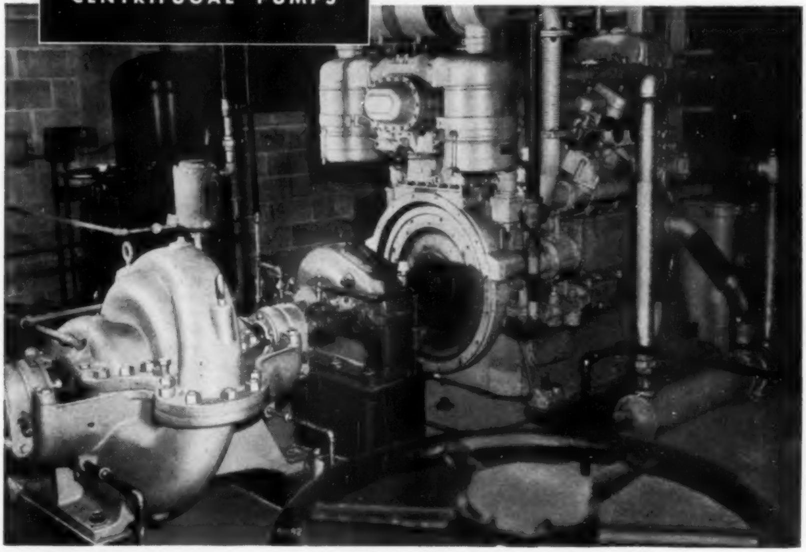
Wooten, Earl J., Sales Repr., Badger Meter Mfg. Co., Greenville, S.C. (Oct. '56) *D*

Ziegler, Melvin H., Sales Engr., Infilco, Inc., Field Office, 1811 Pinal Rd., Golden, Colo. (Oct. '56) *RP*

DE LAVAL

TWO-STAGE CENTRIFUGAL PUMPS

boost pressure at peak loads in Port Washington, New York



This De Laval two-stage horizontal split-case pump is one of a pair used to boost pressure during peak hours in the Port Washington, New York water works. Taking water from a large underground storage tank, these De Laval units maintain pressure throughout the system. The dependable centrifugal pumps are powered by Caterpillar diesels with speed increasers; they deliver 1500 gpm at 400 feet tdh with 15 feet lift requiring 185 bhp.

De Laval 2IS-2KS pumps are designed with • back-to-back impellers for balanced hydraulic thrust • easily replaceable threaded impeller wearing rings • long-life labyrinth case rings • ring-oiled ball bearings — plus ten other important design features. They are available in sizes from 2 inch to 8 inch discharge, for capacities to 3000 gpm and heads to 750 feet. *Write for Bulletin 1501 giving complete data.*

Consulting Engineer:
Angus D. Henderson
Westbury,
Long Island, N. Y.

Contractor:
D. Fortunato, Inc.
Floral Park,
Long Island, N. Y.

DE LAVAL *Centrifugal Pumps*

DE LAVAL STEAM TURBINE COMPANY

822 Nottingham Way, Trenton 2, New Jersey

DL 357A

Index of Advertisers' Products

Activated Carbon:
Industrial Chemical Sales Div.
Permutit Co.

Activated Silica Generators:
Omega Machine Co. (Div., B-I-F Industries)
Wallace & Tiernan Inc.

Aerators (Air Diffusers):
American Well Works
Carborundum Co.
General Filter Co.
Infilco Inc.
Permutit Co.
Walker Process Equipment, Inc.

Air Compressors:
Allis-Chalmers Mfg. Co.
DeLaval Steam Turbine Co.

Alum (Sulfate of Alumina):
American Cyanamid Co., Heavy Chemicals Dept.
General Chemical Div.

Ammonia, Anhydrous:
General Chemical Div.
John Wiley Jones Co.

Ammoniators:
Fischer & Porter Co.
Proportioneers, Inc. (Div., B-I-F Industries)
Wallace & Tiernan Co., Inc.

Ammonium Silicofluoride
American Agricultural Chemical Co.

Brass Goods:
American Brass Co.
M. Greenberg's Sons
Hays Mfg. Co.
Mueller Co.

Calcium Hypochlorite:
John Wiley Jones Co.

Carbon Dioxide Generators:
Infilco Inc.
Walker Process Equipment, Inc.

Cathodic Protection:
Electro Rust-Proofing Corp.
Harco Corp.

Cement, Portland:
Monolith Portland Midwest Co.

Cement Mortar Lining:
Centriline Corp.

Chemical Feed Apparatus:
Cochrane Corp.
Fischer & Porter Co.
Graver Water Conditioning Co.
Infilco Inc.
F. B. Leopold Co.
Omega Machine Co. (Div., B-I-F Industries)
Permutit Co.
Proportioneers, Inc. (Div., B-I-F Industries)
Ross Valve Mfg. Co.
Simplex Valve & Meter Co.
Wallace & Tiernan Inc.

Chemists and Engineers:
(See Professional Services)

Chlorination Equipment:
Builders-Providence, Inc. (Div., B-I-F Industries)
Everson Mfg. Corp.
Fischer & Porter Co.
Proportioneers, Inc. (Div., B-I-F Industries)
Wallace & Tiernan Inc.

Chlorine Comparators:
Klett Mfg. Co.
Wallace & Tiernan Inc.

Chlorine, Liquid:
John Wiley Jones Co.
Wallace & Tiernan Inc.

Clamps and Sleeves, Pipe:
James B. Clow & Sons
Dresser Mfg. Div.
M. Greenberg's Sons
Mueller Co.
Rensselaer Valve Co.
Skinner, M. B., Co.
A. P. Smith Mfg. Co.
Smith-Blair, Inc.
Trinity Valley Iron & Steel Co.

Clamps, Bell Joint:
James B. Clow & Sons
Dresser Mfg. Div.
Skinner, M. B., Co.

Clamps, Pipe Repair:
James B. Clow & Sons
Dresser Mfg. Div.
Skinner, M. B., Co.
Trinity Valley Iron & Steel Co.

Clarifiers:
American Well Works
Chain Belt Co.
Cochrane Corp.
Dorr-Oliver Inc.
General Filter Co.
Graver Water Conditioning Co.
Infilco Inc.
Permutit Co.
Walker Process Equipment, Inc.

Condensers:
Alco Products, Inc.
Allis-Chalmers Mfg. Co.
United States Pipe & Foundry Co.

Contractors, Water Supply:
Layne & Bowler, Inc.

Controllers, Liquid Level, Rate of Flow:
Builders-Providence, Inc. (Div., B-I-F Industries)
Fischer & Porter Co.
Foxboro Co.
General Filter Co.
Infilco Inc.
Minneapolis-Honeywell Regulator Co.
Simplex Valve & Meter Co.

Copper Sheets:
American Brass Co.

Copper Sulfate:
General Chemical Div.
Phelps Dodge Refining Corp.
Tennessee Corp.

Corrosion Control:
Alco Products, Inc.
Calgon, Inc.
Philadelphia Quartz Co.

Couplings, Flexible:
DeLaval Steam Turbine Co.
Dresser Mfg. Div.
Philadelphia Gear Works, Inc.

Diaphragms, Pump:
Dorr-Oliver Inc.
Southern Pipe & Casing Co.

Engines, Hydraulic:
Ross Valve Mfg. Co.

Engineers and Chemists:
(See Professional Services)

Feedwater Treatment:
Allis-Chalmers Mfg. Co.
Calgon, Inc.
Cochrane Corp.
Graver Water Conditioning Co.
Hungerford & Terry, Inc.
Infilco Inc.
Permutit Co.
Proportioneers, Inc. (Div., B-I-F Industries)

Ferric Sulfate:
Tennessee Corp.

Filter Materials:
Anthracite Equipment Corp.
Carborundum Co.
General Filter Co.
Infilco Inc.
Johns-Manville Corp.
Northern Gravel Co.
Permutit Co.
Carl Schleicher & Schuell Co.
Stuart Corp.

Filters, incl. Feedwater:
Cochrane Corp.
Dorr-Oliver Inc.
Graver Water Conditioning Co.
Infilco Inc.
Permutit Co.
Proportioneers, Inc. (Div., B-I-F Industries)
Roberts Filter Mfg. Co.
Ross Valve Mfg. Co.

Filters, Membrane (MF):
AG Chemical Co.
Millipore Filter Corp.
Carl Schleicher & Schuell Co.

Filtration Plant Equipment:
Builders-Providence, Inc. (Div., B-I-F Industries)
Chain Belt Co.
Cochrane Corp.
Filtration Equipment Corp.
General Filter Co.
Graver Water Conditioning Co.
Hungerford & Terry, Inc.
Infilco Inc.
F. B. Leopold Co.
Omega Machine Co. (Div., B-I-F Industries)
Permutit Co.
Roberts Filter Mfg. Co.
Simplex Valve & Meter Co.
Stuart Corp.
Wallace & Tiernan Inc.

Fittings, Copper Pipe:
Dresser Mfg. Div.
M. Greenberg's Sons
Hays Mfg. Co.
Mueller Co.

Fittings, Tees, Ells, etc.:
Alco Products, Inc.
Cast Iron Pipe Research Assn.
James B. Clow & Sons
Crane Co.
Dresser Mfg. Div.
M & H Valve & Fittings Co.
Trinity Valley Iron & Steel Co.
United States Pipe & Foundry Co.
R. D. Wood Co.

Flocculating Equipment:
Chain Belt Co.
Cochrane Corp.
Dorr-Oliver Inc.
General Filter Co.
Graver Water Conditioning Co.
Infilco Inc.
F. B. Leopold Co.
Permutit Co.
Stuart Corp.

Fluoride Chemicals:
American Agricultural Chemical Co.

Fluoride Feeders:
Fischer & Porter Co.
Omega Machine Co. (Div., B-I-F Industries)
Proportioneers, Inc. (Div., B-I-F Industries)
Wallace & Tiernan Co., Inc.

Furnaces:
Jos. G. Pollard Co., Inc.

Gages, Liquid Level:
Builders-Providence, Inc. (Div., B-I-F Industries)
Infilco Inc.
Minneapolis-Honeywell Regulator Co.
Simplex Valve & Meter Co.
Wallace & Tiernan Inc.

Gages, Loss of Head, Pressure of Vacuum, Rate of Flow, Sand Expansion:
Builders-Providence, Inc. (Div., B-I-F Industries)
Foxboro Co.
Infilco Inc.
Minneapolis-Honeywell Regulator Co.
Jos. G. Pollard Co., Inc.
Simplex Valve & Meter Co.
Wallace & Tiernan Inc.

Gasholders:
Bethlehem Steel Co.
Chicago Bridge & Iron Co.
Hammond Iron Works
Pittsburgh-Des Moines Steel Co.

Gaskets, Rubber Packing:
James B. Clow & Sons
Johns-Manville Corp.

Gates, Shear and Sluice:
Armco Drainage & Metal Products, Inc.
Chapman Valve Mfg. Co.
James B. Clow & Sons
Mueller Co.
R. D. Wood Co.

Gears, Speed Reducing:
DeLaval Steam Turbine Co.
Philadelphia Gear Works, Inc.

Glass Standards—Colorimetric Analysis Equipment:
Klett Mfg. Co.
Wallace & Tiernan Inc.

Goosenecks (with or without Corporation Stops):
James B. Clow & Sons
Hays Mfg. Co.
Mueller Co.

Hydrants:
James B. Clow & Sons
Darling Valve & Mfg. Co.
M. Greenberg's Sons
Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co., Inc.
M & H Valve & Fittings Co.
Mueller Co.
A. P. Smith Mfg. Co.
Rensselaer Valve Co.
R. D. Wood Co.

Hydrogen Ion Equipment:
Wallace & Tiernan Inc.

Hypochlorite; see Calcium Hypochlorite; Sodium Hypochlorite

Ion Exchange Materials:
Allis-Chalmers Mfg. Co.
Cochrane Corp.
General Filter Co.
Graver Water Conditioning Co.
Hungerford & Terry, Inc.
Infilco Inc.
Permutit Co.
Roberts Filter Mfg. Co.

Iron, Pig:
Woodward Iron Co.

Iron Removal Plants:
American Well Works
Chain Belt Co.
Cochrane Corp.
General Filter Co.
Graver Water Conditioning Co.
Hungerford & Terry, Inc.
Infilco Inc.
Permutit Co.
Roberts Filter Mfg. Co.
Walker Process Equipment, Inc.

Jointing Materials:
Hydraulic Development Corp.
Johns-Manville Corp.
Keasbey & Mattison Co.
Leadite Co., Inc.

Joints, Mechanical, Pipe:
American Cast Iron Pipe Co.
Cast Iron Pipe Research Assn.
James B. Clow & Sons
Dresser Mfg. Div.
Trinity Valley Iron & Steel Co.
United States Pipe & Foundry Co.
R. D. Wood Co.

Leak Detectors:
Jos. G. Pollard Co., Inc.

Lime Slakers and Feeders:
Dorr-Oliver Inc.
General Filter Co.
Infilco Inc.
Omega Machine Co. (Div., B-I-F Industries)
Permutit Co.
Wallace & Tiernan Inc.

Magnetic Dipping Needles:
W. S. Darley & Co.

Meter Boxes:
Ford Meter Box Co.
Pittsburgh Equitable Meter Div.

M. Greenberg's Sons
Johnson, Edward E., Inc.
R. D. Wood Co.

Surface Wash Equipment:
Cochrane Corp.
Permutit Co.

Swimming Pool Sterilization:
Builders-Providence, Inc. (Div., B-I-F Industries)
Fischer & Porter Co.
Omega Machine Co. (Div., B-I-F Industries)
Proportioneers, Inc. (Div., B-I-F Industries)
Wallace & Tiernan Inc.

Tanks, Steel:
Alco Products, Inc.
Bethlehem Steel Co.
Chicago Bridge & Iron Co.
R. D. Cole Mfg. Co.
Graver Water Conditioning Co.
Hammond Iron Works
Pittsburgh-Des Moines Steel Co.

Tapping-Drilling Machines:
Hays Mfg. Co.
Mueller Co.
A. P. Smith Mfg. Co.

Tapping Machines, Corp.:
Hays Mfg. Co.
Mueller Co.

Taste and Odor Removal:
Builders-Providence, Inc. (Div., B-I-F Industries)
Cochrane Corp.
General Filter Co.
Graver Water Conditioning Co.
Industrial Chemical Sales Div.
Infilco Inc.
Permutit Co.
Proportioneers, Inc. (Div., B-I-F Industries)
Wallace & Tiernan Inc.

Tenoning Tools:
Spring Load Mfg. Corp.

Turbidimetric Apparatus (For Turbidity and Sulfate Determinations):
Wallace & Tiernan Inc.

Turbines, Steam:
Allis-Chalmers Mfg. Co.
DeLaval Steam Turbine Co.

Turbines, Water:
Allis-Chalmers Mfg. Co.
DeLaval Steam Turbine Co.

Valve Boxes:
James B. Clow & Sons
Ford Meter Box Co.
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
Trinity Valley Iron & Steel Co.
R. D. Wood Co.

Valve-Inserting Machines:
Mueller Co.
A. P. Smith Mfg. Co.

Valves, Altitude:
Golden-Anderson Valve Specialty Co.
W. S. Rockwell Co.
Ross Valve Mfg. Co., Inc.
S. Morgan Smith Co.

Valves, Butterfly, Check, Flap, Foot, Hose, Mud and Plug:
Builders-Providence, Inc. (Div., B-I-F Industries)
Chapman Valve Mfg. Co.
James B. Clow & Sons
DeZurik Corp.
M. Greenberg's Sons
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
Mueller Co.
Henry Pratt Co.
Rensselaer Valve Co.
W. S. Rockwell Co.
S. Morgan Smith Co.
R. D. Wood Co.

Valves, Detector Check:
Hersey Mfg. Co.

Valves, Electrically Operated:
Builders-Providence, Inc. (Div., B-I-F Industries)
Chapman Valve Mfg. Co.
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
Golden-Anderson Valve Specialty Co.
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
Mueller Co.
Philadelphia Gear Works, Inc.
Henry Pratt Co.
Rensselaer Valve Co.
W. S. Rockwell Co.
A. P. Smith Mfg. Co.
S. Morgan Smith Co.

Valves, Float:
James B. Clow & Sons
Golden-Anderson Valve Specialty Co.
Henry Pratt Co.
W. S. Rockwell Co.
Ross Valve Mfg. Co., Inc.

Valves, Gate:
Chapman Valve Mfg. Co.
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
Dresser Mfg. Div.
Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co., Inc.
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
W. S. Rockwell Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Hydraulically Operated:
Builders-Providence, Inc. (Div., B-I-F Industries)
Chapman Valve Mfg. Co.
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
DeZurik Corp.
Golden-Anderson Valve Specialty Co.
Kennedy Valve Mfg. Co.
F. B. Leopold Co.
M & H Valve & Fittings Co.
Mueller Co.
Philadelphia Gear Works, Inc.
Henry Pratt Co.
Rensselaer Valve Co.
W. S. Rockwell Co.
A. P. Smith Mfg. Co.
S. Morgan Smith Co.
R. D. Wood Co.

Valves, Large Diameter:
Chapman Valve Mfg. Co.
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
Golden-Anderson Valve Specialty Co.
Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co., Inc.
M & H Valve & Fittings Co.
Muller Co.
Henry Pratt Co.
Rensselaer Valve Co.
W. S. Rockwell Co.
A. P. Smith Mfg. Co.
S. Morgan Smith Co.
R. D. Wood Co.

Valves, Regulating:
DeZurik Corp.
Foster Eng. Co.
Golden-Anderson Valve Specialty Co.
Minneapolis-Honeywell Regulator Co.
Mueller Co.
Henry Pratt Co.
W. S. Rockwell Co.
Ross Valve Mfg. Co.
S. Morgan Smith Co.

Valves, Swing Check:
Chapman Valve Mfg. Co.
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
Golden-Anderson Valve Specialty Co.
M. Greenberg's Sons
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
W. S. Rockwell Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Venturi Tubes:
Builders-Providence, Inc. (Div., B-I-F Industries)
Infilco Inc.
Simplex Valve & Meter Co.

Waterproofing:
Barrett Div.
Inertol Co., Inc.

Water Softening Plants: see Softeners

Water Supply Contractors:
Layne & Bowler, Inc.

Water Testing Apparatus:
Wallace & Tiernan Inc.

Water Treatment Plants:
American Well Works
Chain Belt Co.
Chicago Bridge & Iron Co.
Cochrane Corp.
Dorr-Oliver Inc.
Fischer & Porter Co.
General Filter Co.
Graver Water Conditioning Co.
Hammond Iron Works
Hungerford & Terry, Inc.
Infilco Inc.
Permutit Co.
Pittsburgh-Des Moines Steel Co.
Roberts Filter Mfg. Co.
Walker Process Equipment, Inc.
Wallace & Tiernan Inc.

Well Drilling Contractors:
Layne & Bowler, Inc.

Wrenches, Ratchet:
Dresser Mfg. Div.

Zeolite: see Ion Exchange Materials

A complete Buyers' Guide to all water works products and services offered by AWWA Associate Members appears in the 1955 AWWA Directory.

LEADITE

Trade Mark Registered U. S. Pat. Office

Jointed for . . .
Permanence
with LEADITE

Generally speaking, most Water Mains are buried beneath the Earth's surface, to be forgotten,—they are to a large extent, laid for permanency. Not only must the pipe itself be dependable and long lived,—but the joints also must be tight, flexible, and long lived,—else leaky joints are apt to cause the great expense of digging up well-paved streets, beautiful parks and estates, etc.

Thus the "jointing material" used for bell and spigot Water Mains MUST BE GOOD,—MUST BE DEPENDABLE,—and that is just why so many Engineers, Water Works Men and Contractors aim to PLAY ABSOLUTELY SAFE, by specifying and using LEADITE.

Time has proven that LEADITE not only makes a tight durable joint,—but that it improves with age.

The pioneer self-caulking material for c. i. pipe.
Tested and used for over 40 years.
Saves at least 75%

THE LEADITE COMPANY
Girard Trust Co. Bldg. Philadelphia, Pa.

No Caulking